2015
GEORGIA COTTON PRODUCTION GUIDE

COOPERATIVE EXTENSION / THE UNIVERSITY OF GEORGIA
COLLEGE OF AGRICULTURAL AND ENVIRONMENTAL SCIENCES

UGA COTTON WEB PAGE
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THE 2014 CROP YEAR IN REVIEW

The 2014 production season was certainly different from that of the 2012 and 2013 seasons in Georgia. Harvested cotton acreage increased approximately two percent from that of 2013, with an estimated 1,370,000 acres harvested in Georgia during 2014, according to the National Agricultural Statistics Service (NASS). Georgia remains the 2nd largest cotton producing state in the union, second only to Texas. The 2014 season brought growers a much different scenario than the very wet 2013. Widespread heavy rains and cool weather in early spring delayed planting slightly later than normal, pushing much of the initial planting into mid May, when warm temperatures returned and rains were less intense or frequent. During late April and early May, the weather had already delayed corn planting, and thus delayed planting of peanuts and lastly cotton. However, by late May growers had caught up on cotton planting to near average rates. Timely rains continued through June, leading to vigorous growth during the prebloom period. However, rains subsided and dry weather prevailed in many areas beginning in July. This shift from wet to hot, dry weather occurred when early planted cotton began blooming and severe wilting was quickly noticed in dryland fields. Several growers in Southwest Georgia especially reported six to eight weeks of severe drought stress, forcing early planted dryland fields in to a premature, yet abrupt, cutout. As a result, much of the early planted dryland crop was earlier maturing than normal, with compact fruiting towards the bottom of the plant. Yields in irrigated fields remained quite strong in 2014 as expected. In contrast to the wet 2012 and even wetter 2013 seasons, the potential benefits of irrigation were clearly observed in many areas during 2014. Later planted dryland cotton, especially in Southeast Georgia, appeared to fair slightly better in general.

The most common challenges for growers in 2014, in addition to dry weather during bloom, included a few isolated incidences of plant bugs early in the season, and a few cases of armyworms later in the year. Although thrips are a very consistent early season insect pest for Georgia growers, thrips pressure was heavier than what is normally expected during the later part of the planting window. As previously mentioned, rains were sparse in much of July and August, however rains returned in September, as bolls began to open in early planted cotton. These early fall rains resulted in some boll rot and or hardlock, but also caused significant regrowth problems in nearly all fields defoliated and harvested prior to early/mid October. A two week cloudy spell resulted in suboptimal defoliation, however harvest progressed fairly rapidly throughout the fall due to the earlier than normal maturity of the dryland crop. As of November 9th, 2014, harvest was approximately 18 percent ahead of schedule, according to NASS. First frost occurred across most of the state around November 1st, which is a week to 10 days earlier than normal.

Glyphosate-resistant pigweed continues to be a significant challenge, but many of our growers have been very proactive about addressing this weed pest. Despite these and other challenges, many parts of Georgia were blessed with higher than expected yields, resulting in a projected statewide average yield of 911 lbs/A (as of November 1st, 2014). Georgia is expected to produce 2,600,000 bales during 2014, sustaining our commitment to cotton. Although yields were variable depending upon rainfall, average statewide yields continue to remain above 800 lbs/acre, which is a true testament to Georgia's growers, their commitment to cotton, and the release of superior varieties. As modern varieties are currently being released onto the market in a much more rapid manner, due to increased competition and advancements by industry, variety selection remains a very important and costly issue, however many of the new varieties performed very well for Georgia growers in 2014. The 2014 cotton acreage in Georgia was predominately comprised of Deltapine varieties (58.99%), FiberMax varieties (6.48%), Stoneville (15.36%), and Phytogen varieties (14.42%) (http://www.ams.usda.gov/AMSv1.0/).

Quality of the 2014 crop was comparable to previous years for some parameters. Of 931,588 bales classed as of November 13, 2014, 5.6 percent were short staple (<34) and 15.3 percent were high mic (>4.9). Average staple was slightly lower than that of the previous two years, and the incidence of short staple was slightly higher than this time last year. Average micronaire was slightly lower than in 2013 but the incidence of high mike was noticeably lower in 2014 compared to 2013. Fiber length uniformity remained high in 2014, a likely result of the constant changing in varieties planted. The incidence of bark was similar to that of 2013, but noticeably lower than in 2012, but continued to be slighty higher than in years preceding 2011.

Fiber Quality of Bales Classed by mid November to early December at the Macon USDA Classing Office, 2008-2014

	Color Grade 31/41 or better (% of crop)	Bark/ Grass/ Prep (% of crop)	Staple (32nds)	Strength (g/tex)	Mic	Uniformity
2008	25 / 93	all < 1.0	34	28.7	46	80.2
2009	26 / 96	all < 1.0	35	28.8	45	80.3
2010	50 / 90	all < 1.0	35	29.9	48	81
2011	38 / 84	2.6 / <1 / 1	36	29.6	46	81.7
2012	46 / 91	6.5 / <1 / <1	36	29.1	47	81.5
2013	57 / 98	2.6 / <1 / <1	35.9	29.7	48	81.7
2014	56 / 84	2.5 / <1 / <1	35.3	28.7	47	81

Bales classed short staple (< 34) and high mic (>4.9)
2008: 20% & 21% 2009: 22% & 20% 2010: 4% & 9% 2011: 2.8% & 8.8%
2012: 1.4% & 20.5% 2013: 1.1% & 30.1% 2014: 5.6% & 15.3%
Fiber quality data as of November 13, 2014. Source: http://www.ams.usda.gov/AMSv1.0/

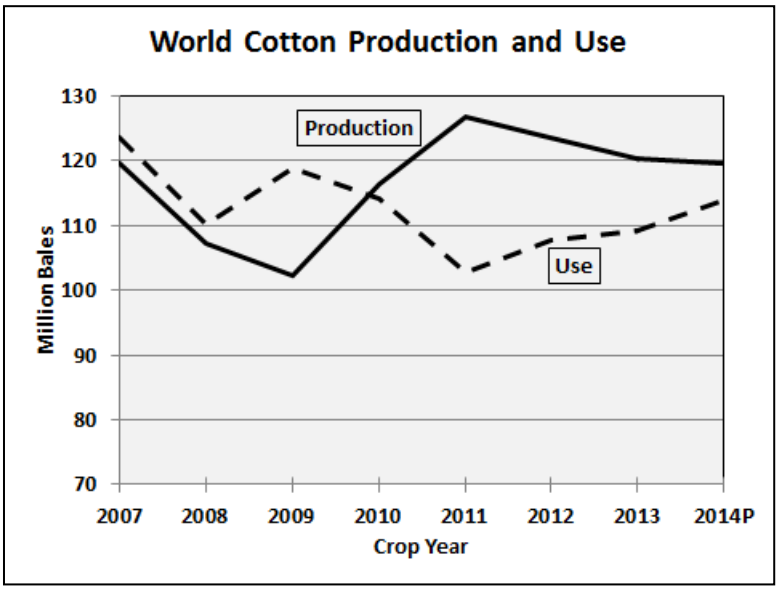
COTTON ECONOMICS, MARKETING, AND POLICY FOR 2015.

Georgia farmers planted 1.38 million acres of cotton in 2014—up slightly from 2013. The state average cotton yield for 2014 is currently estimated at 911 lbs per acre. This is better than the 831 lbs last season but below the 1,091 lbs in 2012. Prices for the 2014 crop have declined almost 25% since the highs reached prior to and during the planting season. Prices for the 2015 crop are also currently low. Entering the 2015 crop year, final rules and regulations on the farm bill are known and landowners and producers will have important decisions to make.

Price Situation and Outlook

2014 cotton prices were dominated by improved US crop conditions and increased production. This seemed to overshadow most other supply/demand factors. The US crop declined from earlier estimates but still 27% above 2013 and prices (Dec14 futures) declined over 20%.

World Use/demand improved for 2014-15 but crops came in better than expected in India, China, and Pakistan. World production was down slightly from 2013 and Ending Stocks continued to grow. China's announced price support and import policies also dampened the market.



Prices for the 2015 crop (Dec15 futures) are currently around 65 cents. This is not profitable and cotton acreage may decline in 2015. This depends, however, on prices and expected net returns of alternative crops. Prices for other row crops have also declined and not as attractive as in past years. Peanut price opportunities may not be known until closer to planting time.

For some growers, soybeans appear the most likely alternative to cotton in 2015. Corn is around $4.00/bushel; soybeans have also declined but still almost $10.00/bushel. Peanuts are expected to attract acreage due to the likelihood of a PLC payment.

In some cotton-growing states and areas, peanuts are not an alternative and/or corn and soybeans do not have the agronomic and comparative economic advantage as in other areas. In these situations, cotton is more stable and may decline only slightly if at all even at these low prices.

Overall, US cotton acreage will likely decline in 2015. Acreage in the Mid-South and in the Carolinas and Virginia will likely decline, perhaps significantly. Acreage in Texas and Georgia-Florida-Alabama may also decline but much less.

Prices for 2015 will be shaped by US acreage and production, foreign production (most notably in China with the new target price subsidy program), World demand, and China's stocks and imports. World demand has been improving from the low in 2011. If this uptrend continues and US and World production declines, this could provide support for prices.

This does not mean cotton is likely to return to 80 cents or better. It does mean, however, that with Dec15 futures currently near 65 cents, there could be more upside potential than downside risk. The current expected range in 2015 price is mostly 65 to 75 cents.

LDP When Prices are Low

The "loan repayment rate" on cotton is the loan rate plus interest and storage charges or the Adjusted World Price, whichever is less. When the Adjusted World Price (AWP) is less than the Loan Rate, a Loan Deficiency Payment (LPD) or Market Loan Gain (MLG) is realized.

If the producer stored cotton under the Loan and his/her Loan Rate was 52 cents/lb and the AWP was 47 cents, the loan could be paid off at 47 cents and the producer would realize a gain (MLG) of 5 cents/lb. Alternatively, the producer could keep the 52 cent loan and accept a "merchant equity" payment in addition to the loan. The merchant would continue to carry the cotton in Loan if so desired. The equity payment should be an amount that would be equivalent to the producer paying off the loan and selling the cotton net of any charges.

An LDP is a payment received in lieu of placing cotton in the Loan. The math is the same as just described—if the Loan Rate is 52 cents and the AWP is 47 cents, the producer may apply for and receive an LDP of 5 cents but the cotton would no longer be eligible for Loan. Producers still commonly refer to this as a "POP" payment. Cotton, even cotton already contracted and priced, is eligible for LDP as long as the producer has "beneficial interest" in the cotton.

The producer may even apply for an LDP while the cotton is still in the module. The primary advantages of this is to protect from the LDP possibly going down, to protect from the market price going down, and/or to possibly avoid losing beneficial interest.

Here is an example of how the LDP/MLG is calculated. The A-Index is the weekly average price for the 5 cheapest cotton's (lowest prices) for 31-3/35 cotton delivered f.o.b. the port in China. For the week of November 28-December 4, 2014, the A-Index was 66.05 cents/lb. From this price, 19.69 cents is subtracted for transportation costs back to the US and for US base quality of 41-4/34. This gives an AWP of 46.36 cents/lb.

Since this is less than the Loan Rate of 52 cents, subtracting the AWP from the Loan Rate gives an LDP/MLG of 5.64 cents. This is the LDP/MLG that will be in effect for the following week beginning December 5.

Example Calculation of AWP and LDP/MLG on 2014 Cotton	
Nearby US Cotton Futures Average (11/28-12/4)	59.74
A-Index (Far East Price) 11/28-12/4	66.05
Adjustments for Grade and US Location	-19.69
Adjusted World Price (AWP)	**46.36**
Base Loan Rate	52.00
Loan Deficiency Payment (LDP/MLG) 12/5-11	**5.64**

The World Price (A-Index) and US futures prices tend to track together; not always penny for penny and day to day, but over time they have a tendency to move in the same direction. This means as the A-Index goes up/down, US prices also tend to go up/down and vice versa. This means the producer can maximize total money received when the A-Index and AWP move down in relation to US prices or when US prices move up in relation to the A-Index.

In the example shown for that week, US cotton futures averaged 6.3 cents below the World Price or A-Index. Given this spread between US and World price, there would be no LDP/MLG if US futures prices are above about 65 cents.

If prices for the 2015 crop remain at or below current levels, producers can expect another LDP/MLG situation for 2015. Prices have not been low enough to trigger LDP's

Comparative Net Returns of Cotton and Other Crops

The following is an early (preliminary) comparison of expected net returns for 2015. Prices for all crops are down from previous years and profit margins are likely to be tight for 2015. Peanuts appear to be the only potential bright spot, but based solely on the expected contract price for only a portion of the crop. Otherwise, this analysis is based on 2015 harvest time futures prices as of early December 2014.

Because prices do and will change, the best way to use this analysis is as a comparison or ranking only. As prices change, the dollar amount of net returns will change; but, if all prices change proportionately the same, the rankings will not change.

Based on these prices, yield, and cost assumptions, peanuts offer the highest potential net return for both irrigated and non-irrigated production. Among the four crops considered, cotton currently would rank last in non-irrigated production but corn, soybeans, and cotton all appear to offer about the same net return. In non-irrigated production, cotton would have to be 77 cents to equal the net return of $415/ton peanuts. If peanuts were $363 per ton, this would be the same potential net return as cotton at 65 cents.

In irrigated production, peanuts again offer the highest net return, followed by soybeans, then cotton. The price needed for cotton to equal $415/ton peanuts is 70 cents/lb. Peanuts at $387/ton would be equal to cotton at 65 cents.

Preliminary Comparison and Ranking of 2015 Estimated Net Returns, Non-Irrigated

	Corn	Cotton	Peanuts	Soybeans
Expected Price[1]	$4.25	$0.65	$415	$9.75
Average Yield	85	750	1.7	30
Per Acre Crop Income[2]	$361	$488	$706	$293
Variable Costs[3]	$305	$440	$570	$240
Net Return Per Acre	**$56**	**$48**	**$136**	**$53**

1/ Prices are 2015 harvest time futures price as of December 2014, adjusted for expected basis. Peanut price is expected contract price. Season average prices may vary; this analysis is for ranking and comparison only.
2/ Excludes any PLC or ARC payment if applicable; excludes any STAX payment on cotton.
3/ Preliminary, adjusted from 2014 estimates.

Preliminary Comparison and Ranking of 2015 Estimated Net Returns, Irrigated

	Corn	Cotton	Peanuts	Soybeans
Expected Price[1]	$4.25	$0.65	$415	$9.75
Average Yield	200	1,200	2.35	60
Per Acre Crop Income[2]	$850	$780	$975	$585
Variable Costs[3]	$665	$540	$670	$315
Net Return Per Acre	**$185**	**$240**	**$305**	**$270**

1/ Prices are 2015 harvest time futures price as of December 2014, adjusted for expected basis. Peanut price is expected contract price. Season average prices may vary; this analysis is for ranking and comparison only.
2/ Excludes any PLC or ARC payment if applicable; excludes any STAX payment on cotton.
3/ Preliminary, adjusted from 2014 estimates.

Assignment of Covered Commodities to Generic Base. The cotton Base on a farm is now called "Generic Base". This Generic Base (old cotton base) cannot be increased or decreased. It will remain fixed for the life of the new farm bill (2014-2018). Each year, the reported acreage planted of all "covered commodities" on the farm will be "assigned" by FSA to the Generic Base, and for that year only, become temporary base of that crop. The most common covered commodities in Georgia are canola, corn, grain sorghum, peanuts, soybeans, wheat and oats for grain or grazing, and sunflowers.

The acreage planted to all covered commodities will be assigned to Generic Base—up to the maximum of the Generic Base. If the acreage planted to all covered commodities is less than the Generic Base, all acreage planted will be assigned. If the acreage planted to all covered commodities is more than the Generic Base, the acreage will be assigned based on each crops percentage of the total planted.

Example Allocation of Covered Commodities to Generic Base and Total of All Bases

Generic Base Acres	**120.00**				
Acres Planted to Covered Commodities		**Percent Allocation**	**Temporary Base**	**Retained or Reallocated Base**	**Total Base Acres**
Canola	0.00	0.00%	0.00	0.00	0.00
Corn	31.00	22.30%	26.76	35.60	62.36
Grain Sorghum	0.00	0.00%	0.00	0.00	0.00
Oats	0.00	0.00%	0.00	0.00	0.00
Peanuts	88.00	63.31%	75.97	81.10	157.07
Soybeans	0.00	0.00%	0.00	10.50	10.50
Sunflowers	0.00	0.00%	0.00	0.00	0.00
Wheat	20.00	14.39%	17.27	10.50	27.77
Total Covered Commodities	**139.00**	**100.00%**	**120.00**	**137.70**	**257.70**

In this example, the farm has a total of 257.7 acres of Base—137.7 acres of covered commodity bases (all bases except cotton, as the result of the decision to retain or reallocate) and 120 acres of Generic Base (old cotton base). For 2015, the producer plants a total of 139 acres of all covered commodities on the farm. Because this is more than the Generic Base, the acreage planted to covered commodities will be assigned to the Generic Base in proportion to the total acres planted.

For example, 88 acres of peanuts were planted. This was 63.3% of the total 139 acres planted to covered commodities. Applying this percentage to the Generic Base, peanuts will have approximately 76 acres of temporary base for 2015. The farm already had 81.1 acres of permanent peanut base on the farm and will now have a total of 157 acres of peanut base for 2015—the 81 acres of peanut base plus 76 acres assigned from the Generic Base.

If the total acreage planted of all covered commodities is less than the Generic Base, no allocation is necessary. All acreage planted will be assigned to the Generic Base.

This is a temporary one year allocation based on the acreage planted to covered commodities. The allocation of Generic Base for the next year will be determined by the planting of covered commodities that year.

PLC and/or ARC payments, if available, are made on 85% of base acres. Payments are made on the permanent bases regardless of what is planted or not planted. Payments are then also made on the temporary bases determined by what is planted and assigned to Generic base.

STAX (Stacked Income Protection Plan) for Cotton

Beginning with the 2015 crop, STAX is available for cotton. STAX is the "safety net" for cotton. Cotton is not a "covered Commodity" and is not eligible for PLC or ARC.

STAX is a county/area revenue crop insurance plan that is designed to supplement the farm's typical yield or revenue policy (what will now be referred to as the farm's "companion policy"). STAX is optional. It is not required. The producer may choose STAX or not; the producer may choose to have a companion policy or not.

A "coverage band" must be selected. The highest/widest band would be 90% to 70% of county revenue. If this were selected, for example, STAX would pay if Actual County Revenue is less than 90% of the Expected County Revenue and the maximum indemnity (payment) would be 20% (90% - 70%) of the Expected County Revenue. There are 10 possible coverage bands and the protection and premium varies with each.

Coverage is available for both irrigated and non-irrigated county yields if data exists to allow separate yields to be determined. Expected County Revenue is the expected county yield (already determined by USDA-RMA) times the Projected Price. This is the same mid-January to mid-February average December futures prices used on existing revenue products. If Harvest Price Option (HPO) is selected and the Harvest Price (October average price of December futures) is higher than the Projected Price, the Expected Revenue and Guarantee are revised using the higher Harvest Price.

An example is shown for Dooly County, GA assuming the 90-70% coverage band is selected. The projected price (PP) is assumed to be $0.65 per lb. HPO is selected and the harvest price (HP) is assumed to be $0.67 per lb.

Example of STAX Coverage and Payment, Dooly County GA

	Non-Irrigated	**Irrigated**
Expected County/Area Yield Per Planted Acre	688	1193
Projected Price (Assumed as of 12/05/2014)	$0.65	$0.65
Harvest Price (only if HPO is selected)	$0.70	$0.70
Expected County/Area Revenue (Yield x higher of HP or PP)	**$482**	**$835**
Revenue Guarantee (Expected Revenue x 90%)	**$433**	**$752**
EXAMPLE OF STAX PAYMENT:		
Actual County/Area Yield Per Planted Acre	600	1000
Harvest Price	$0.70	$0.70
Actual County/Area Revenue	**$420**	**$700**
A. Revenue Guarantee minus Actual Revenue*	$13	$52
B. Maximum Payment (Expected Revenue x 20% coverage band)	$96	$167
C. Lesser of A or B	$13	$52
Protection Factor (PF)	1.2	1.2
Indemnity Paid (C x PF)	**$16.13**	**$61.91**

**Equals zero if Actual Revenue is greater than Revenue Guarantee*

Expected County Revenue is $482 per acre for non-irrigated and $835 per acre for irrigated. With a coverage band of 90% to 70% selected, the Revenue Guarantee is $443 per acre for non-irrigated and $752 per acre for irrigated.

Actual Revenue is determined using the harvest price regardless of whether HPO is selected or not. Assuming actual county average yields of 600 and 1,000 lbs/acre for non-irrigated and irrigated respectively, Actual Revenue is $13 per acre less than the Guarantee for non-irrigated and $52 per acre less for irrigated.

When purchasing STAX, the producer must select a Protection Factor (PF). This PF will be between .80 and 1.20 and is multiplied by any revenue loss to adjust the actual Indemnity paid up or down.

STAX is optional and producers may also choose SCO (Supplemental Coverage Option) rather than STAX. The following is a comparison of STAX and SCO.

Comparison of STAX and SCO

STAX	SCO
No Companion Policy required	Companion Policy required
Based on county/area revenue	Based on county yield or revenue; same as Companion Policy
Maximum/widest coverage of 90% to 70% of revenue; 20% maximum	Coverage from 86% down to the level of the Companion Policy
May elect to receive indemnity above amount of actual loss (PF)	N/A
80% premium subsidy	65% subsidy premium

FERTILIZATION

With cotton prices expected to be lower than normal this year, it is even more important to follow a sound fertilizer and liming program that is based on good soil sampling. Liming on time (at least 3 months ahead of planting) and where needed is the first step to assuring maximum uptake of both nutrients already in the soil and those applied as fertilizer. Variable rate liming based on grid or zone sampling may also be more effective and economical than "blanket" applications of lime. Nitrogen rates should be based on yield goals as explained below, and should be split applied to again assure maximum uptake and efficiency. Potassium needs to be applied at planting and possibly later as foliar to avoid what has become the most common nutrient problem in Georgia cotton in recent years. Ten pounds of sulfur needs to be included either at preplant or with sidedress N. And a half of pound of boron per acre is still the standard recommendation for cotton to assure proper pollination and fruiting and thus yield. More details can be found below, but following this basic plan should assure good economically produced cotton yields.

Lime

The official UGA recommendation or "target" pH (water) for cotton is 6.0. However, a field with an average pH of 6.0 may very well have large areas measuring below this target pH. Recent precision soil sampling techniques have indicated that this happens frequently. Therefore, growers using standard soil sampling techniques are encouraged to maintain their soil pH for cotton between 6.0 and 6.3. Liming to pH values above 6.3 may cause manganese deficiency problems in the Flatwoods soil region. However, this problem can be handled easily with applications of foliar Mn during the growing season. Liming to between 6.0 and 6.3 for all soil regions in Georgia is critical for proper uptake and utilization of nutrients that are essential for plant growth. Fertilizer use efficiency is also best in this range. In addition, toxic elements such as aluminum (Al) are kept unavailable when pH is above 5.5.

There are many factors that affect the soil pH reading obtained from soil testing. Possible reasons for seeing abrupt changes in soil pH include 1) sampling variability (spatial and depth), 2) rainfall amounts and 3) nitrogen fertilizer usage. Even so, changes of more than 0.5 in soil pH in one year should be considered suspect and call for resampling.

Dolomitic lime (that has 6 % or more Mg) is still a common liming material used on Georgia cotton and provides magnesium (Mg) as well as calcium (Ca) and a pH adjustment. The use of calcitic lime (less than 6% Mg) is becoming more popular in Georgia every year and may be used in cases where high soil Mg levels occur. **If calcitic lime is used for consecutive years, soil test**

Mg levels should be tracked closely with soil testing. As soon as soil test Mg levels start to drop out of the high range into the medium range, the use of dolomitic lime should be resumed. The reason for this is that dolomitic lime is the most economical source of Mg fertilizer. In addition, a good liming program should supply all the Ca that a cotton plant needs for high yields and quality. Calcium deficiency in cotton is very rare, and the need for foliar Ca applications or small doses of supplemental Ca applied to soil should not be necessary.

Phosphorous and Potassium

Phosphorous (P) and potassium (K) levels in soil should be maintained in the upper medium range as determined by soil testing. All of the P requirements should be applied preplant since it is relatively immobile in soil and is important to seedling growth. All of the K requirements should also be applied preplant on all soil types including Piedmont, Coastal Plain, and Deep Sand soils. Widespread K uptake and deficiency problems continue to occur in Georgia cotton every year.). This problem is also made evident by weak areas in the fields (usually in sandy washed out areas) and the presence of certain leafspots. Cercospora, Alternaria and Stemphylium leafspot have all been linked to potassium deficiency. These leafspot diseases are considered secondary to potassium deficiency and if potassium deficiency is avoided then these leafspots should not be an issue. The relatively new Corynespora leafspot, however, does not appear to be linked to potassium deficiency.

Split applications of K, especially half the recommended rate at planting and half at sidedress, have also not proven to be effective on Tifton type soils. In fact, in some cases this approach may lead to potassium deficiency before sidedress applications are made. Recent field trials conducted in Georgia have focused on additional soil-applied K during N sidedressing versus foliar K applications during peak bloom (first 4 weeks of bloom). Preliminary results from studies conducted on Coastal Plain soils indicate that foliar K may be more effective than sidedress K in improving yields. Research on Deep Sands is still needed to determine which approach is more effective. **Currently, foliar K applications should automatically be considered on deep sands (more than 18 inches to subsoil clay), low K soils, high Mg soils, high-yielding conditions, short season varieties and especially, where severe K deficiencies and leafspot have been observed in the past.** Two foliar applications of 5-10 lbs/K2O in each application during early bloom (first thru 4th week of bloom) should be considered in these situations.

Because current cotton varieties are relatively fast fruiting and early in maturity, this makes them more susceptible to K deficiency. In most situations, the best strategy to avoid K deficiency is to 1) soil test, 2) apply the recommended K fertilizer at planting, and 3) consider foliar feeding K during peak bloom.

Currently, there are a number of commercially available fertilizer additives that are designed to improve the uptake efficiency of P and K fertilizers. Research results with Georgia cotton showing consistent advantages to these materials have not been seen at this time and their widespread adoption is not recommended.

Nitrogen Management

Nitrogen is probably the most important fertilizer used on cotton, yet it is the most difficult to manage. Low N rates can reduce yield and quality while excessive N rates can cause rank growth, boll rot, delayed maturity, difficult defoliation, and poor quality and yield. Total N rates for cotton should be based on soil type, previous crop, growth history, and yield potential. Base N rates recommended by the UGA Soil Testing Lab according to yield goals are listed below.

Yield Goal (lb lint/A)	Recommended N Rate (lb N/A)
750	60
1000	75
1250	90
1500	105

These N rates should then be adjusted according to other factors. For example:

Increase N rate by 25% if:	Decrease N rate by 25% if:
Deep sandy soil	Cotton following peanuts or soybeans
Cotton following cotton	Cotton following good stands of winter legumes such as clover or vetch
History of inadequate stalk growth	History of rank or excessive vegetative growth

Yield goals should always be realistic, preferably based on past production records. For N rates above 100 lb/A, cotton should be highly managed in terms of insect control, plant height, and boron fertilization. Total N rates above 120 lb/A should only be needed on deep sands or in special cases of history of inadequate stalk growth or where excessive leaching has occurred. The N rates for 1250 and 1500 lb lint/A yield goals assume irrigation.

The total N rate should always be applied in split applications. Apply 1/4 to 1/3 of the recommended N at planting and the remainder at sidedress. The preplant or at planting N application is critical for getting the crop off to a good start and ensuring adequate N nutrition prior to side-dressing. **Sidedress N between first square and first bloom** depending on growth and color (toward first square if slow growing and pale green, toward first bloom if rapid growth and dark green). A portion of the sidedress N can also be applied as foliar treatments or through irrigation systems**. No N should be soil-applied (either top dressed or through the pivot) after the 3rd week of bloom.** Studies have shown that uptake of soil-applied N from by cotton roots is basically ineffective after this critical point.

There are a number of sidedress nitrogen fertilizer materials that can be used on cotton including liquid UAN solutions, ammonium nitrate and urea. UAN solutions are made up of urea and ammonium nitrate and often contain sulfur (e.g. 28-0-0-5). Ammonium nitrate is losing favor as a sidedress N source for cotton due to higher cost and burn potential. Urea is considered an alternative to ammonium nitrate but is known to be prone to volatilization losses. Volatilization losses can be minimized however by irrigating after a urea application or by use of a urease inhibitor that contains the active ingredient NPBT. Another liquid N solution that is gaining popularity as a sidedress N source for cotton is “19 %” or 18-0-0-3(S). These sources are derived from a by-product of the Attapulgite clay mining industry in southwest Georgia and are made up approximately 60 % nitrate and 40 % ammonium (no urea). Replicated, small plot research trials conducted between 2010-2013 indicate that 18-0-0-3(S) is comparable to 28-0-0-5(S) in terms of producing cotton yield. Feed grade urea is still the product of choice for foliar N applications later in the growing season. Controlled release nitrogen foliar products are also available but usually contain potassium and boron and are less concentrated in N.

Sulfur

The official UGA fertilizer recommendation for sulfur is 10 lb/A. Sulfur can be applied either with preplant fertilizer or with sidedress N materials such as 28-0-0-5 or ammonium sulfate. Sulfur fertilization is most important on sandy, low organic matter Coastal Plain soils. With less

S input from cleaned ("scrubbed") power plant smokestack emissions and the recent trend toward high-analysis (S-free) fertilizers, including S in a cotton fertilizer program is currently very critical. Adequate S fertilization is also important where higher rates of fertilizer N are used. Since S deficiency symptoms are similar to N deficiency (yellowing) and the N:S ratio in plant tissue is a good indicator of S nutrition, a plant tissue sample greatly aids in diagnosis when low S is suspected.

Boron

Boron (B) is an essential micronutrient that is important to flowering, pollination, and fruiting of the cotton plant. The standard **UGA recommendation of 0.5 lb B/A**, applied in two 0.25 lb/A foliar applications between first square and first bloom, fulfills the base requirement for B. Single applications of 0.5 lb B/A can be used but include a greater risk of foliar burn. Foliar applications above the base recommendation of 0.5 lb B/a and up to 2 lb B/A (applied in increments of no greater than 0.5 lb B/A per application) may help move nitrogen and carbohydrates from leaves into developing fruit. Cumulative applications totaling above 2 lb B/A, however, may reduce yields and quality. The need for additional B above the 0.5 lb/A rate is best determined by tissue or petiole testing. Since B leaches readily through sandy soils, foliar applications have always been considered the most effective and efficient application method. However, on a typical Coastal Plain soil like the Tifton series, with normal rainfall and irrigation, preplant, starter, and sidedress soil applications are also be considered effective. If no B is included in preplant, starter, or sidedress soil-applied fertilizer applications, is foliar B alone (with no insecticide or growth regulator) worth the trip? Yes, especially on sandier soils and with irrigation or adequate rainfall.

Numerous B fertilizer materials are currently available. Most are either derived from boric acid or sodium borate and can be either in the liquid or wettable powder form. There are many "additives" used with these base B materials such as nitrogen and complexing agents designed to improve efficiency of uptake. However, extensive field testing over recent years has proven that all of the B fertilizers currently on the market are equally effective in terms of plant nutrition. Therefore, choice of B fertilizers should be made on price per pound of B.

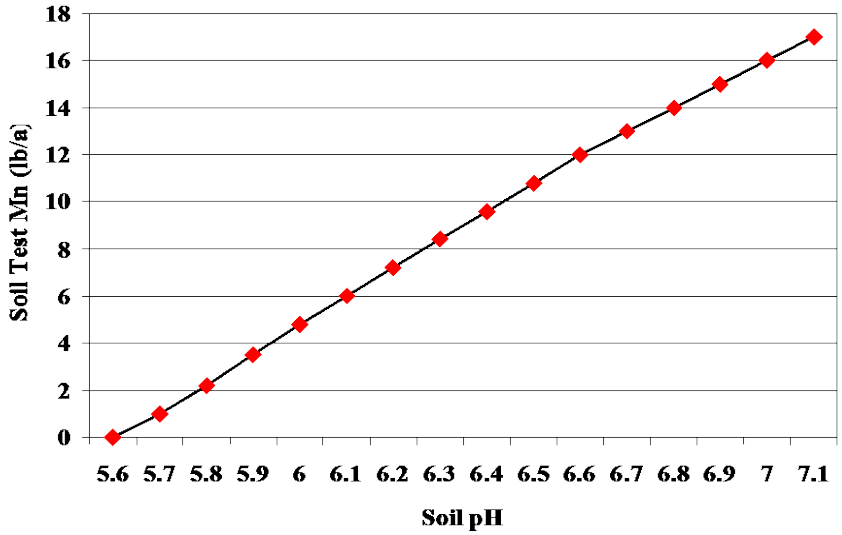
In addition, at least one boron fertilizer currently sold in Georgia is recommended at application rates well below the recommended 0.5 lb B/A rate -- in fact the labeled rate only provides 0.025 lb B/A !. **As far as fulfilling the base recommendation for B, any boron fertilizer recommended at a rate that does not provide at least 0.25 lb B/a should be considered uneconomical !**

Manganese and Zinc

Manganese (Mn) and zinc (Zn) are two essential micronutrients that are routinely measured in soil testing at UGA and can sometimes be deficient in cotton. Both Mn and Zn are less available for plant uptake at higher soil pHs. Therefore, soil test results should be examined closely for the combination of low levels of Mn or Zn and high soil pH.

In order to minimize the chance of Mn deficiency on cotton, minimum levels of soil test manganese should be maintained with varying pH levels as shown in Figure 1.

Figure 1. Relationship between pH and manganese availability. Maintain soil test manganese levels above the line to help avoid manganese deficiency. Source: Soil Test Handbook for Georgia



Notice on the graph, that if soil pH is at the recommended target of 6.0, soil test level of Mn should be at least 5 lb/A. At soil pH of 6.5 the soil test level of Mn should be at least 11 lb/A.

Even when the soil test level of Mn falls below the recommended level for a given pH, the result is not an automatic recommendation to apply Mn fertilizer. Instead, the crop should be monitored using tissue testing between first square and first bloom and foliar Mn can be applied if a deficiency is confirmed. Small amounts of Mn can also be added to starter fertilizer applications. Be sure to read and apply Mn and other micronutrients starter packages according to label to avoid burn and stand loss.

Large amounts of soil applied Mn (above 5 lb/A) are not considered to be economical. Therefore, in situations where soil test levels of Mn need to be built up, do so slowly and monitor the crop for deficiency using tissue testing. In essence, if a grower likes to maintain soil pH near the UGA target pH of 6.0, then soil test Mn should be built to and maintained around 5 lb Mn/A. If the grower likes to maintain soil pH at a higher level, say around 6.5, then the soil test level of Mn needs to be built to and maintained around 11 lb/A.

Cotton growers in the Flatwoods soil region are cautioned not to maintain soil pH above 6.3 to minimize the chance of Mn deficiency (peanuts and soybeans are also susceptible to Mn deficiency at this pH on these soils). If soil pH is maintained above 6.3 on these soils, tissue testing is recommended regardless of soil test Mn levels in order to avoid deficiencies. If a deficiency is detected in this situation, it can be corrected by foliar feeding Mn.

Soil test levels of zinc should be maintained between 2 and 8 lb/A (Mehlich 1 extractant) . Unlike Mn, if soil test Zn falls below this range, it is considered low and an application of zinc fertilizer will be recommended. The recommended Zn fertilizer can be applied with broadcast preplant fertilizer or more efficiently, with a starter fertilizer application. In the event that no zinc is applied to the soil even though recommended by soil testing, a foliar application of zinc can be made. Tissue testing in both cases, whether Zn was applied to soil or applied foliar, is

recommended. The tissue sample should be taken between first square and first bloom. Tissue sampling at first square is better than at first bloom in order to correct the deficiency before the crop experiences any possible reduction in yield.

Deficiencies of the other essential micronutrients including copper, iron, chlorine, and molybdenum in Georgia cotton are extremely rare.

Petiole and Tissue Testing

The University of Georgia used to offer a 10-week petiole testing program for monitoring the N and K status and for making N, K, and B foliar applications. Leaf stems (petioles) were sampled weekly from the same field starting the week before first bloom and analyzed for N, P, and K. Depending on the relationship between N and P, along with other information such as soil moisture and fruit load, foliar N and/or B was recommended. Potassium levels were also monitored and in the case of K deficiency, soil-applied or foliar K applications will be recommended. A valuable feature of petiole testing programs was that weekly sampling tracked nutrient level trends and allowed the detection of deficiencies or excesses up to 2 weeks in advance. Due to labor and time costs, Georgia cotton growers were not utilizing the 10-week petiole testing program at UGA and therefore it has been discontinued.

Petiole testing for troubleshooting is still available and can still be a valuable tool for making in-season correction of certain nutritional problems (namely N and K). "Spot checking" with petiole sampling can be done as many weeks during the fruiting period as desired. Simply sample the petioles and send them to UGA or a private lab for analysis and a recommendation of where the typical nitrate and K levels should be for that week of bloom.

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Tissue testing (the leaf blade without the petiole) is also available through both the University of Georgia lab and private labs and can be especially helpful to detect deficiencies of nutrients not included in petiole testing. Tissue testing is used differently than petiole testing in that it is more important for correcting nutritional problems prior to bloom and can detect different nutritional problems such as with magnesium, sulfur manganese and zinc. The most common growth stage when cotton leaf tissue is sampled is early bloom, the same time as the first petiole sampling. However, tissue sampling can be helpful earlier during the "vegetative" stage to detect and correct early nutrient problems. Tissue sampling can also be used any time during the growing season when trouble shooting if samples are taken from both normal ("good") and affected ("bad") areas of a field.

Since petiole and tissue samples tell different things, it is recommended that both are taken during troubleshooting (especially when past the first bloom stage). For example, petiole samples appear to be a better indicator for N and K deficiency than tissue samples when troubleshooting, but tissue samples are useful for detecting S deficiency (based on the N:S ratio) and micronutrient deficiencies. Also, petiole samples analyzed as tissue samples and vice versa will result in useless information. For example, measuring the nitrate level in a tissue sample or total N in a petiole cannot be interpreted since no data are available for these measurements.

Foliar Fertilization

Foliar fertilization of cotton should be used to supplement a good soil-applied fertilizer program. The most likely nutrients needed for foliar applications are N, B, and K. Foliar N applications can be made as part of an overall N management strategy or as determined by petiole testing. Feed grade urea is the most reliable, economical, and proven foliar N material. The standard recommendation is for 4.5 lb N/A as urea in 5 gal or more of water (5gal/A assumes aerial

application). Both liquid (23 % N) and granular urea (46 % N dissolved into water) can be used. Applying all the recommended K to soil preplant or at-planting should provide sufficient K for Georgia cotton in most cases**.** Potassium nitrate is the most common material used for foliar K applications. The standard recommendation is for 4.4 lb K_2O /A in 5 gal or more of water. Again, 5 gal/A assumes aerial application and both liquid and granular KNO_3 can be used. If potassium nitrate is not available, there are other foliar K fertilizers available (for example, liquid 5-0-20) that can also be used to foliar feed K. However, many of these materials do not contain as much K and cannot be applied at rates comparable to potassium nitrate without causing significant leaf burn.

Based on field research trials, foliar fertilization is most effective when applied during peak bloom or the first 4 weeks of bloom. Foliar feeding during the 5^{th} – 7^{th} week of bloom may or may not be effective depending on the particular cotton variety grown**. How late is too late to foliar feed cotton ? Once you pass the 8^{th} week of bloom**, it is too late and no foliar feeding is recommended.

Starter Fertilizers

Although starter fertilizers do not consistently increase cotton yields, they are an effective way of providing early N and P as part of an overall fertility program. Yield responses have been most consistent where soil P levels are low or when planting in cool, wet soils. The use of starter fertilizer is strongly encouraged for conservation tillage systems and in high yield situations. Even though yield responses may not be realized, other advantages include the development of strong root systems and the encouragement of early rapid growth for weed control with directed herbicide sprays.

Ten gal/A of 10-34-0 is probably the most common starter fertilizer treatment used on Georgia cotton. Nitrogen solutions (with or without S) and complete (N-P-K with micronutrients) dry fertilizer materials can also give good results. Recent research conducted in Georgia showed that the choice of starter fertilizer should depend on soil type and conditions. For example, on "red dirt" such as the Greenville series that has a high affinity for P, P-containing materials such as 10-34-0 should be used. On "stiffer" Coastal Plain soils such as the Tifton series that have medium to high soil test P, N-only materials such as 32 % N liquid can be used. On sandy Coastal Plain soils with histories of S problems, N+S materials such as 28-0-0-5S should be considered. An economic evaluation of this same research showed that in 23 out of 30 comparisons, starter fertilizer gave greater economic returns compared to the untreated check. Adding liquid micronutrient packages to liquid starter materials is also gaining in popularity. This may be a good way of providing recommended B, Zn, and Mn in an overall fertilization program.

The recommended placement for any starter fertilizer is 2 inches below and 2 inches to the side of the row (also referred to as "2-by-2"). **No starter fertilizer materials should be placed in direct contact with the seed "in furrow"**. "Dribbling" liquid starter fertilizers on the soil surface, 2 inches to the side of the furrow (to avoid possible leaching into the seed zone) has proven effective on sandy soils but does not work on "stiffer" soils. **Avoid using starter fertilizer rates greater than 15 lb N/A**, even in the 2-by-2 placement, in order to reduce the risk of "starter burn." Under certain conditions -- namely dry, sandy soil -- even 15 lb N/A can burn cotton seedlings if not placed properly.

Starter fertilizers can also be applied in conjunction with herbicide applications by spraying narrow bands (3 to 4 inches) directly over the row behind the press wheel. Mixing liquids containing both N and P with preemergence herbicides can result in clogging of spray nozzles and

can decrease the fertilizer effect (or benefit) by spreading the material in a wider band. However, this may supply some needed N when no other preplant N has been applied. Rates should not exceed 20 lb N/A when this method is used.

Poultry Litter

Managed properly, poultry litter (manure mixed with wood shavings) can be a valuable source of plant nutrients for Georgia cotton. The fertilizer value of poultry litter varies depending on a number of factors including moisture, temperature, feed rations, number of batches before clean-out, storage, and handling. However, broiler litter has an approximate analysis equivalent to 3-3-2 (%N – % P_2O - % K_2O). Based on this average, one ton of broiler litter contains 60 lb/A of N, 60 lb/A of P_2O and 40 lb/A of K_2O. Due to variability, it is recommended that litter be analyzed for nutrients by a reputable laboratory before application rates are determined.

Poultry litter on cotton should be managed to provide preplant P and K and a portion of the total N requirement. The remainder of the N requirement should be applied as commercial fertilizer at sidedressing. For example, 2 tons/A of poultry litter preplant incorporated followed by 30 to 60 lb/A of sidedress N (depending on soil type) is a good, basic strategy. This approach should avoid unnecessary P buildup and should not cause rank growth, boll rot, or defoliation problems typically associated with excess N. In addition, the availability of N from poultry litter, because it is an organic material, is less predictable than from commercial fertilizer. Therefore, side-dressing with commercial fertilizer N assures adequate N availability when the crop needs it the most. The amount and timing of N released from litter depends on a number of factors, including soil pH, temperature, sand content, and available moisture. As a rule of thumb, 60% (or 36 lb N/ton of litter) is made available for crop uptake during the season if the manure is incorporated into the soil prior to planting. Most of the remaining N in the litter (about 40%) is either lost or "tied up" during the growing season and should not be considered for carryover to the next crop. Since N availability from poultry litter can be highly variable, petiole testing is strongly recommended. Build up of soil P and Zn are long-term concerns for using poultry litter as fertilizer. However, at the 2 ton/A rate, there are no short-term concerns for poultry litter use in cotton.

The only situation where poultry litter rates above 2 ton/A should be considered is where problems with "black root" are suspected. Black root is isolated to poorly-drained Flatwoods soils and has not been that prevalent in recent years. Rates of 3 to 4 tons of poultry litter per acre have been shown to alleviate this problem dramatically. However, at the 4 ton/A rate excess soil P will build rapidly. Therefore, this solution should only be considered a short-term fix and not a long-term strategy.

How early can I apply chicken litter for cotton ? In general, it is best to apply any base fertilizer nutrient (inorganic/commercial or organic like chicken littler) close to when a plant needs it, typically 2- 3 weeks before planting. Therefore, ideally, chicken litter would not be applied until around April 1 for May planted cotton. Timing of acquiring litter and availability of labor tempts growers to apply litter as early as December and January. This is not recommended since most of the N and some of the K can be lost before the cotton crop will ever be established (depending on soil type and rainfall). In addition, if a cover crop is grown, the cover crop will take up the nutrients from the litter and greatly decrease the availability to the cotton crop. **If at all possible, delay applying chicken litter for cotton until at least February 1.**

Other By-Products

As landfill costs and regulations increase, more by-products are becoming available for land application on row crops such as cotton. These by-products are not only from the agricultural sector (such as poultry litter), but also from municipalities and industry. Examples include gin trash, mushroom compost, yard waste, biosolids, dairy manure, composts, fly ash, and wood ash. These materials may have some value as fertilizers, soil amendments, or liming materials. They may be free or available at very low cost. However, great caution is needed when considering the use of any by-product to ensure it can be used, safely, effectively, and economically.

Before considering the use of any by-product material on cotton, investigate the properties of the material. Find out what value it has (as either lime, fertilizer, soil amendment, or a combination), if it is safe (for example, low in heavy metal content and free of any toxins), how much it costs, and if it will handle and spread easily. Fortunately, any by-product material to be used as a fertilizer, lime, or soil amendment in Georgia must first be approved by the Department of Agriculture. Since by-products are unique, they should be investigated on a case-by-case basis.

VARIETY SELECTION

Choosing which variety to plant is one of the most critical steps in producing a cotton crop and achieving optimal yields and fiber quality. Currently, producers not only choose a variety based on genetic performance or yield potential, but also according to pest management traits or technology packages. The predominant technology systems that will be available in 2015 include (but aren't necessarily limited to) conventional, Roundup Ready Flex, Bollgard II/Roundup Ready Flex, Widestrike, Widestrike/Roundup Ready Flex, Glytol/Liberty Link/Bollgard II, and GlyTol/Liberty Link/Twinling. It is generally advised that growers should strongly consider spreading their risks by planting multiple varieties. A single dominant variety is unlikely, however official variety trials and on-farm county variety trials in 2010-2014 illustrated that several varieties performed well in several environments. Considerations for variety selection should also be catered to a range of planting dates, seedling vigor, water regimes (irrigated versus dryland and degree/efficiency of irrigation), maturity classes, and plant growth characteristics, with the understanding that some varieties may perform better in certain situations than others.

The average lifespan of cotton varieties is becoming significantly shorter, therefore growers have little time to gain experience with these varieties. Growers must therefore adapt quickly to new varieties and gain as much experience with them as possible within a short time frame. Variety selection at the grower level should be based on research data and local field experience. Attention should be given to both yield and fiber quality. Sources of data include trials from university experiment stations and county demonstration plots, seed company trials, and consultant trials. Results of the UGA On-Farm Cotton Variety Performance Evaluation Program are published on the UGA Cotton Web page at www.ugacotton.com, as well as the UGA Cotton Variety Performance Calculator, which is a valuable and easy tool for growers to use to compare performance of most modern varieties across Georgia. Small-plot UGA Official Variety Trial (OVT) data is also available at www.ugacotton.com as well as http://www.swvt.uga.edu/, and this data is also found in the UGA Cotton Variety Performance Calculator located at www.ugacotton.com. It is very important to observe multi-year and multi-location data when possible, as well as fiber quality characteristics of these varieties, which can also be found at www.ugacotton.com. It is even more important to look for varieties that perform consistently well across locations of a similar environment (irrigated vs. dryland). Some varieties may perform well at a particular location within a year, however their average performance across

similar environments may be much less, which may be an indicator of inconsistency or poor stability. Varieties that perform well across a wide range of environments indicate a high degree of stability, which in turn suggests that these varieties may result in good performance across planting dates, soil types, rainfall patterns and irrigation practices, grower management practices, and other factors. Results from at least two years and several locations often provide a better indication of anticipated performance and stability. Generally, the more years and locations the better, and while data are helpful, grower experience on the farm is the ultimate test. In addition, the adage, "Try a little, not a lot," is still the preferred approach when implementing new technologies, varieties, and production practices on the farm, if possible.

PLANTING DATES

Long term research has shown little yield difference in planting dates between late April and May 20. The "best" planting window varies yearly. Early planting while moisture persists increases the likelihood of successful planting in non-irrigated fields. However, early planting comes with risks, including possible seedling vigor and disease problems associated with cool and/or wet periods, premature cutout related to the coincidence of early fruiting and drought, and late season boll rot due to expected rains in late August or early September. Boll rot is frequent in areas in which boll opening coincides with rainfall, high humidity, and overcast conditions. Seed sprouting from the exposed seedcotton can also be a problem during the fall of some years if similar conditions prevail. In addition to these problems, significant yield loss and quality degradation can occur when lint is exposed to rainfall and wind.

Soil temperature is an important consideration for early planting. Generally, planting can safely proceed when the 4-inch soil temperatures reach 65^{o} F for 3 days and warming conditions are projected over the next several days (or approximately 50 DD-60's within 5 days of planting). Experience suggests that this is a very safe, conservative approach. For optimal emergence, soil temperatures should be 65^{o} F or more during the first 2 to 3 days after planting into moist soil, as imbibed seed are often killed by temperatures of 41^{o} F or below. Cotton seeds and seedlings are most sensitive to cool or cold tempertures during this time frame. Warm temperatures should also be likely within 5 days of planting, as temperatures below 50^{o} F can cause chilling injury to emerging seedlings.

Delaying planting until late April and early May has shown advantages in deep South Georgia. Irrigated cotton should usually be planted after May l, since the risk of having adequate moisture for getting a stand is eliminated, the possibility of boll rot from August rains is reduced, and thrips pressure is lessened. Also, boll opening and harvest-time rainfall risks are reduced and harvest can be accomplished from late September through November, normally period of lower rainfall.

Many South Georgia producers grow both cotton and peanuts. The occurrence of tomato spotted wilt virus (TSWV) has resulted in a shift in peanut planting to mid-May and has also delayed the initiation of peanut harvest to mid-September. Competition for labor at harvest has often forced South Georgia producers to choose between the two crops, most often with cotton harvest being delayed. There is the possibility that early plantings (early to mid-April) and proper management of short season cotton varieties under irrigation may allow harvest prior to peanut maturity. Early planting and subsequent early harvest may also be an avenue to enhance crop quality, as one of the major factors influencing overall crop quality is delayed defoliation and harvest. Potential benefits of this concept depends on favorable weather in early September, but planting a portion of the total crop helps "spread the risk." In some years, cotton that matures and opens in late August or early September is subjected to severe boll rot. In addition, unfavorable weather at boll

opening may in fact undermine the attempt to capture quality with early planting of shorter season varieties. Thus, planting a major portion of ones crop in this way is not advised. The adoption of on-board module building pickers may allow growers to harvest peanuts and cotton simulateously, to the mutual benefit of both crops.

Weather prediction is an important part of agriculture. Ideally, an accurate understanding of future weather could guide planting so that fruiting coincides with abundant rainfall and that boll opening/harvest coincide with relatively rain-free periods. Unfortunately, neither accurate prediction nor control of weather exists. Seasonlong weather--particularly rainfall--continues to be the single greatest factor influencing yield.

Double Crop or Late-Planted Cotton

Double-crop or "June" cotton is feasible in the Coastal Plain, especially in lower South Georgia where the growing season is longer. Early, cool fall weather delays maturity and limits yield in some years, but cotton planted in early June generally has adequate yield potential under intensive management, especially with irrigation. Some UGA research shows a possible yield reduction of up to 30 percent when comparing full-season cotton planted in early May to June planted cotton after wheat harvest. Grower experience indicates increasing risk past the first week of June. The obvious limitation is an early frost or at least cool temperatures in mid to late October which inhibit boll maturation. In addition, because of the brevity of the potential fruiting period, timely rain or irrigation is absolutely necessary. Growers should be aware of crop insurance specifications related to late or double-crop cotton. Research studies along with grower experience indicate the following precautions or adjustments should be made when planting either as a double-crop after small grains or extremely late (near or after June 1):

1. Irrigation is strongly recommended to ensure a vigorous stand, rapid stand establishment, and boll retention during the normally dry period in late May and early June. Likewise, dry weather is expected after mid-August and before boll maturity is completed.
2. Management (PGRs, Fertility, Irrigation etc) for a shorter season crop to maximize boll set and retention during the first 3 to 4 weeks of bloom.
3. Plant only 2 to 3 good quality seed/ft of row to alleviate the complications of late plantings and dense stands.
4. Protect the terminal bud from injury by thrips or worms. Generally, thrips pressure is less in late May and early June plantings as compared to April to mid-May planting dates. Also, prevent plant bug and stink bug damage to avoid delays in fruiting.
5. Avoid crop injury by over-the-top sprays or other misuse of herbicides to prevent stress and delayed maturity.
6. Prevent fruit shed and fruiting gaps by good insect control, balanced nutrition, and irrigation.
7. Don't try to rush the crop by over fertilizing with N. Use minimum soil applied rates (usually 25 to 30 percent less than on full season) and monitor nitrate levels with petiole tests to detect need for late sidedness or foliar N application. P and K could be applied to the previous crop, except for sandy land, to save time especially if a starter is used to give N for early season growth.
8. Monitor the crop closely by plant mapping, square retention counts, etc., so that problems can be diagnosed and corrected to prevent further delays in maturity.
9. Use mepiquat-containing plant growth regulators if needed to prevent excess vegetative growth and boll rot, and to promote earliness.
10. Use ethephon (Prep, Finish, First Pick, etc.) harvest aid to promote boll opening, allow earlier harvest, and avoid freeze damage.

PLANT AND FIBER DEVELOPMENT

Upland cotton (Gossypium hirsutum) is a perennial, tropical plant that has been bred and adapted for annual crop production in temperate climates. Cotton develops on a somewhat predictable schedule, although water and temperature stresses may have profound effects on growth rate.

Plant monitoring and mapping help determine if the plant is growing and fruiting normally. Assuming a lack of moisture stress or injury from one of many potential above or below ground pests, plant growth is primarily influenced by temperature. Plant development proceeds approximately according to a heat unit model which uses 60° F as the base temperature. In this system, heat units are referred to as DD-60s and are calculated based on an average daily temperature °F minus 60° F. The formula is as follows:

$$\frac{\text{Max } ^{o}\text{F} + \text{Min } ^{o}\text{F}}{2} - 60\ ^{o}\text{F} = \text{DD-60s}$$

For example, a day with a maximum of 86° F and a minimum temperature of 70° F produces 18 DD-60s, [(86 + 70 / 2) - 60 = (156/ 2) - 60 = 78 - 60 = 18 DD-60's]. Temperatures above 93° F should be entered in the formula at only 93° F since growth probably does not increase at higher temperatures. Current and historical heat unit accumulations for numerous locations across the state can be referenced at the website for the Georgia Automated Environmental Monitoring Network (www.georgiaweather.net) via the UGA cotton web page at www.ugacotton.com . For numerous locations across the state, this Network website allows calculation of current heat unit accumulation and comparison with data from recent years.

The following chart estimates growth rate based on accumulated DD-60s. Because growth and development are dependent on many factors in addition to temperature, these numbers are only approximations. A detailed discussion of cotton plant growth and development can be found in UGA Extension Bulletin #B1252 at http://pubs.caes.uga.edu/caespubs/pubcd/B1252.htm.

		DD-60's	Days
From Planting to:	Emergence	50	4 to 14
	Pinhead square	550	35 to 45
	First bloom	940	55 to 70
	Peak bloom	1700	85 to 95
	First open boll	2150	115 to 120
	Harvest	2500 to 2700	140 to 160

Plant Growth Monitoring

Monitoring cotton growth rate gives an index of vigor and should usually be initiated by the 8 to 10 leaf stage. Because of the variability of row profiles and cultivation practices, plant height should be measured from cotyledons to the terminal bud, not from the ground up. Cotyledons are the pair of seed leaves first observed after emergence. They are attached to the mainstem directly opposite from each other. By general agreement across the Cotton Belt, the node at the point the

cotyledons are attached is counted as Node 0. As growth progresses, the cotyledon leaves fall off, leaving two small nodes near the base of the plant.

The first true leaf is Node 1 and should be visible in the terminal within 7 to 10 days after emergence. Subsequent mainstem leaves will emerge at approximately 3-day intervals (4 days under cool or stressed conditions). These leaves occur singly at each node and the stem area between each leaf or node is called the internode. Fruiting branches (FB) normally begin to develop at node 5 to 7 from one of the two tiny buds in the leaf axil or point at which the mainstem leaf is attached. Fruiting branches develop a fruiting bud or square with a subtending leaf at 6-day intervals (possibly 7 to 9 day intervals under stress conditions) at one to three or more positions along the branch (referred to as FB1 for first position, FB2, etc.). The subtending leaf is a major source of photosynthate for the square, which flowers after about 21 days, and the boll, which develops and matures over a 6-week period after flowering. Vegetative branches (usually 2 or 3 per plant) develop at nodes or mainstem leaves below the first FB and sometimes from the second bud adjacent to a FB if the FB is injured. The goal for FB1 square retention at early bloom should be 80 percent. Experience in Georgia and in many other environments suggests that extremely high early retention rates may actually limit yields by limiting vegetative growth and total fruiting sites.

Cotton plants usually develop 21 to 23 nodes but an aggressive full-season varieties, may develop in excess of 25 nodes or mainstem leaves in long growing seasons with adequate moisture and/or moderate boll loads. Nodes beginning with numbers 5 to 7, and up to 20 to 22 potentially develop fruiting branches on which harvestable bolls develop. Cutout usually occurs when fewer than 5 nodes or mainstem leaves remain above the uppermost white flower (NAWF) at the first position (FB1). Boll retention in the top 2 to 3 nodes is usually very low since the plant is normally in cutout due to boll load, water, and/or nutrient stress.

Research indicates the crop can be defoliated when the uppermost, harvestable green boll is 4 nodes above the uppermost cracked boll (NACB = 4) without sacrificing yield and quality. When NACB is 5 or more, some yield or quality may be lost. Looking at this question from a different angle, a boll is sufficiently mature after accumulating about 750 DD-60s.

Plant Selection and Sampling for Monitoring Purposes

Usually, 20 normal plants should be counted / measured from each field beginning at the 8 to 10 leaf stage and on a weekly basis for maximum learning and database establishment. However, "short-cut" sampling where 8 to 10 plants or measurements are checked may be more practical for growers, county agents, and consultants.

Avoid plants with:

- ☐ Damaged terminals
- ☐ Spacings not like field average or plants next to skips or in clumps. Select the dominant plant in hill-dropped cotton
- ☐ 20 percent taller or shorter than field average.

Note: The following values are approximate and not well-defined by Georgia research

1. Plant Height (inches). Measure only from cotyledons to terminal bud.

2. Height/Node Ratio (HNR). Average plant height divided by total mainstem nodes = HNR or Vigor Index (inch/node).

	Vigor Index (Height/Node Ratio)		
Crop Stage	Normal	Stressed	Vegetative
Seedling Cotton =	0.5 to 0.75	-	-
Early Squaring =	0.75 to 1.2	0.7	>1.3
Large Square-1st bloom	1.2 to 1.7	<1.2	>1.9
Early bloom =	1.7 to 2.0	<1.6	>2.5
Early bloom + 2 weeks	2.0 to 2.2	<1.8	>2.5

3. Nodes Above White Flower (NAWF) at first position on fruiting branch (FB1):

Growth Stage	NAWF
Early Bloom	8 to 10
Peak Bloom	7 to 8
Cutout	<5

4. Ideal Plant (in very general terms)
   Height = 44 to 50 inches
   Total Nodes = 22 to 24
   HNR = 1.8 to 1.9
   First Fruiting Branch = node 6
   Fruiting Branches = 12 to 14
   Boll Retention = 67 percent or 8 to 10 FB1 bolls
   Cutout = begins node 18 to 20

Managing the crop according to information obtained by plant monitoring is not yet possible due to lack of enough baseline data and environmental control under Georgia conditions. Generally, when monitoring indicates the plant is stressed or growing abnormally, the cause should be determined and corrected as soon as possible. Timely soil, petiole, and tissue analysis can detect nutrient deficiencies or excesses. Of course, water stress can only be relieved by timely rain or irrigation. Stress may also be caused by herbicide injury, disease, nematode injury, soil compaction, and temperature extremes.

Mepiquat containing plant growth regulators can be used to regulate excess vegetative growth. If excessive vegetative growth is due to fruit loss, the cause of fruit loss should be detected quickly, especially if related to insects. Other causes of fruit loss may include cloudy weather, heat/drought stress, heavy boll load, and cutout. Maximum yields can be obtained by optimizing growth conditions through proper management.

Fiber Quality and Development

A cotton fiber is a single cell that generates from the surface of the seed and elongates resembling a hollow tube. Fiber quality issues in Georgia gained significant attention concerning the 2003 crop, however the release of new varieties in recent years has drastically improved fiber quality of Georgia cotton. In any given year, due to environmental conditions, light spot grades, short staple, and high micronaire may be encountered, therefore it is important to understand fiber development and important quality parameters, and potential actions that could help avoid discounts.

Fiber length uniformity is a calculation determined by dividing the average fiber length by the average of the upper half fiber lengths (staple). This is difficult to comprehend, but in essence, the uniformity index reflects how many short fibers are present. Short fibers lower yarn strength, reduce spinning efficiency, limit the use of lint for certain yarns, and increase imperfections in yarn. Uniformity can be influenced significantly by variety, boll feeding bugs, weathering of the open crop, and ginning. Relative comparisons of crop quality can be made by examining the Statewide Cotton Variety Testing data as well as other sources. The effect of boll feeding bugs on yield is well documented and we continue to learn about their effects on overall fiber quality. Weathering problems are aggravated by the limits of our harvest capacity, the interference of peanut harvest with cotton harvest (although the adoption of on-board module building pickers may help alleviate this issue), and our reluctance to push the crop toward rapid defoliation, boll opening, and harvest. Ginning can also have a profound affect on fiber uniformity. Excess heat (drying) and lint cleaning can result in breakage of fibers and reduce uniformity.

The two most important stages of development are fiber elongation and "thickening." Elongation occurs primarily during the first 20 days after flowering, while thickening (internal deposition of cellulose within the fiber) occurs from about 15 to 20 days after flowering and continues for about 30 days (until 45 days after flowering). Inside the "tube," rings or strands of cellulose are layered each day, intertwining and providing strength to the fiber.

The measure of elongation is staple, and the measure of internal fiber thickness is micronaire, often abbreviated as mike or sometimes mic. Variety, weather patterns, and boll feeding pest control play a role in determining fiber length and micronaire. Micronaire reflects the internal surface area or fill of the cotton fiber; that is, the thickness of the rings/layers formed within the cell. High or low micronaire generally corresponds to thicker or thinner deposites of cellulose, respectively. High micronaire (above 4.9) is usually associated with moisture or heat stress. Such conditions reduce boll set or boll size and concentrate carbohydrate production in fewer or smaller bolls, increasing cellulose deposition within individual fibers and increasing micronaire. Conversely, if stresses such as early frost or premature defoliation (from whiteflies, rain scald, etc.) curtail the development of bolls, <u>low</u> mic (below 3.5) may result. Low micronaire penalties are uncommon in Georgia, although a few early harvested bales in 1999 were docked for low micronaire because of late season whitefly damage, rain scald, and premature defoliation.

Certain varieties have a tendency towards high mic, although the environment has the greatest influence on the final outcome and mic value. In fact, because high micronaire means a slightly thicker and probably heavier fiber, cotton breeders recognize that elevated micronaire is often a quick step to higher yield. High micronaire generally means coarse fibers which have reduced spinning efficiency, and has implications concerning dye uptake.

Fiber quality is influenced by numerous factors, including weather, management, variety, and ginning. Both length and micronaire are influenced by environmental conditions. WHEN stress occurs determines the characteristic most affected.

PLANT POPULATION / SEEDING RATE

Aim for a final stand of 2 to 3 plants/ft of row. Calibrate planters to deliver 2.5 to 4 seeds/ft (2 to 3 in irrigated fields) depending on soil-type. Increase planting rate if seed quality is poor or in fields in which seedling diseases, soil crusting, or otherwise poor emergence are expected to be a problem. Calibrate planters for each variety to be planted. Seed sizes of different varieties range from 4000 to 6500 seed/lb and significantly affect the number of seed planted. Therefore, final rates may range from less than 6 to more than 8 lb/A. Thick stands (5 or more plants/ft) are undesirable but sometimes occur unintentionally. They can produce satisfactory yields under careful management of nitrogen, moisture, and insects, though dense stands tend to increase the node number at which plants begin fruiting.

Because the "per acre" technology costs of transgenic varieties are directly linked to seeding rates, growers are often tempted to minimize the number of seed/ft. In research trials conducted from 1995 to 1997, rates as low as 2 seed/ft resulted in plant stands ranging from 1.2 to 1.9 plants/ft and maximum lint yield over the 3 year study. Practically, a target of 2.5 seed/ft is a reasonable trade-off for economizing with expensive transgenic cotton. In a hill-drop planting system, which is often used to overcome the adverse effects of soil crusting, this seeding rate would be equivalent to 2 seed every 8 to 10 inches**.** Reducing seeding rates below 2.5 seed/ft often increases the chance of poor stand establishment and adverse effects on plant canopy structure or architecture, especially if environmental conditions are not suitable for rapid stand establishment. Skippy stands can reduce yields, delay maturity, and allow sunlight penetration through the canopy to be utilized by weeds.

PLANTING

"Knock-off" beds and plant in the center of a smooth uniform surface 12 to 16 inches wide. Wet beds may need to be leveled 1 to 4 hours ahead of planting. Equip planters with 6 to 8 inch wide depth bands or gauge wheels, or 12 to 16 inch wide gauge shoes to provide seed depth control and smooth drill area. Set planters to place seed 0.5 to 1 inch deep. Shallower planting may be more appropriate if soil crusting occurs or if other emergence complications are expected. The shallow depth range is also preferred for "dusting in" in dry soil and/or cool-weather planting, a greater planting depth is preferred for warmer weather planting if moisture is sufficient at planting and for several days thereafter. Cotton is very sensitive to deep planting, especially in crusting soils or when soil moisture depletes rapidly. Open center press wheels and low press wheel loading are preferred to minimize soil crusting. Planter adjustments may need to be made on a field-by-field basis to ensure optimal soil-to-seed contact.

If "rip-plant" equipment is used, off-set row drill 2 to 3 inches to one side of ripper shanks to reduce risk of stand loss from "fall-in." Contamination of the preplant incorporated herbicide treated zone with untreated soil resulting in grass emergence in the drill occasionally occurs behind ripper-planters. This can be minimized by using ripper shanks with a sharp rather than flat leading edge and by not planting in wet soil.

With good soil moisture and warm temperatures at planting, seedlings usually begin to emerge in 5 to 7 days with full stand in 8 to 11 days, but can be delayed or complicated by seedling diseases or rapid moisture depletion. Physical hazards to establishing stands that occasionally occur during this period include hard soil crusts and blowing sand. The adverse effects of both can be greatly reduced with rotary hoe or rolling cultivator operations. These implements should be operated just deep enough to break the crust. An irrigation of 0.3 to 0.5 inches can be used to

soften or weaken a crust and accomplish the same objective. Timing this operation is critical. If a hard crust is evident when the seed root is 0.6 to 0.75 inches long, it should be broken immediately, being careful not to completely uproot more than 20 to 25 percent of the seedlings. Soil crust strength can be measured with a small pocket penetrometer. Emergence decreases rapidly at soil strengths above 10 psi especially when cotton is planted deeper than 1 inch.

INSECT MANAGEMENT

Cotton insect management has changed dramatically since the successful elimination of the boll weevil as an economic pest and the commercialization of Bt transgenic cotton. Prior to elimination of the boll weevil, Georgia producers annually applied 10 to 20 insecticide treatments each season for control of boll weevils and other pests. Upon elimination of the boll weevil as an economic pest, the number of insecticide applications was reduced to four or five during 1992 to 1995. Utilization of Bt cotton, commercialized in 1996, has further reduced the need for insecticides by eliminating the need to treat tobacco budworm and significantly reducing the need to treat for corn earworm. Producers in Georgia continue to fully utilize an integrated approach to pest management (IPM) utilizing a variety of control tactics rather than relying solely on one method of control such as insecticide use. Cultural practices, variety selection, biological control, and insecticides used on an as-needed basis are the building blocks of an IPM program. Pests are managed so that economic damage and harmful environmental side effects are minimized while maximizing profits. In most IPM programs insecticide use decreases resulting in lower production costs, delayed resistance problems, and improved competitiveness and profitability. A successful and economical cotton pest management program mandates the use of this multi-tactical or IPM approach to insect control.

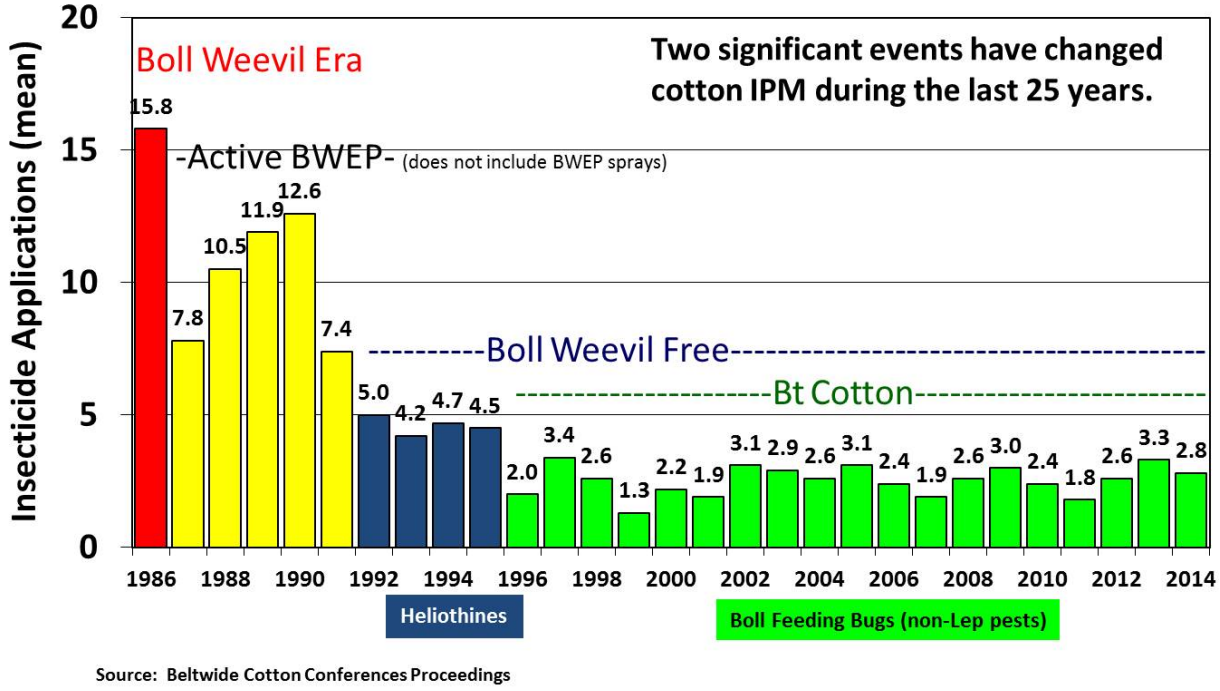

Figure 1. Mean insecticide applications applied on Georgia cotton, 1986-2014. The Boll weevil Eradication Program was initiated during the fall of 1986.

Scouting

Insect scouting is a **necessity**. All fields, both Bt and non-Bt cotton, should be scouted on a regular basis. Insect populations vary from year to year and even from field to field during the year. Fields should be scouted at least every five days, some scouts monitor fields twice per week. Although not recommended, once a week scouting may be acceptable on Bt cotton but there is associated risk with this reduction in field visits. **Once a week scouting on non-Bt cotton is unacceptable**. Management decisions should be made independently for each field based on the pest(s) situation. Accurate monitoring of fields will allow growers to make timely applications of the correct insecticide(s) and rates to prevent damage from reaching economic levels. (See ***Cotton Scout Handbook*** for a detailed discussion of insects and scouting techniques and the Cotton Insect Control tables below for insecticides, rates, and thresholds.)

Beneficial Insects

Several species of predatory and parasitic insects are present in Georgia cotton. These natural controls are our most economical pest management tools and conservation of beneficial populations should be considered especially during early season. Big-eyed bugs, minute pirate bugs, fire ants, and *Cotesia* wasps are four important beneficial insects. The presence of these natural controls may delay the need to treat for some insect pests. The use of natural controls should be maximized in attempts to reduce production costs.

Thresholds

Action or economic thresholds have been established for major cotton insect pests and are defined as the pest density at which action must be taken to prevent economic damage. The decision to apply an insecticide should be based on scouting and the use of thresholds. Thresholds for major cotton insects found in the Cotton Insect Control tables below should serve as a guide for decision making. **Scheduled or automatic applications of insecticides should be avoided**. An unnecessary application can be more costly than just the cost of the insecticide due to the destruction of beneficial insects. In the absence of beneficial insects, the risk of economic infestations for many pests increases. Application of insecticides on an as-needed basis allows beneficial insects to be preserved and reduces the likelihood of secondary pest outbreaks such as beet armyworm and spider mites.

Resistance Management

In a population of insects, insecticide resistance levels to a particular class of insecticide increase each time that class of insecticide is used. Once an insecticide is used, its level of effectiveness will likely be reduced against subsequent generations within the season. Therefore **alternating the use of insecticide classes on different generations** of insects during the season is a recommended resistance management tactic. Since most cotton insect pests are highly mobile, such a strategy will be most effective if adopted by all producers in a large geographic area.

Thrips Management

Thrips are consistent and predictable pests of seedling cotton that infest cotton at emergence. Thrips initially feed on the lower surface of cotyledons and then in the terminal bud of developing seedlings. Excessive feeding results in crinkled malformed true leaves, stunted plants, delayed maturity, reduced yield potential, and in severe cases reduced stands.

At-plant systemic insecticides provide consistent yield responses and are used by most growers for early season thrips control. In-furrow applications or seed applied systemic insecticides are taken up by the plant as it germinates and develops providing protection during early growth stages. Commonly used at plant thrips insecticides include the neonicotinoid seed treatments imidacloprid (Gaucho, and Aeris Seed Applied System) and thiamethoxam (Cruiser

and Avicta Complete Cotton). Infurrow spray applications of imidacloprid or acephate at planting are also options for early season control of thrips.

Supplemental foliar sprays may be needed if environmental conditions are not conducive for uptake of at-planting systemic insecticides or if heavy thrips infestations occur. Systemic foliar insecticides should be applied to cotton which had an at-plant systemic insecticide when 2-3 thrips per plant are counted and immatures are present. The presence of numerous immatures suggests that the at-plant systemic insecticide is no longer active. If no at-plant thrips insecticide is used, multiple well timed foliar applications will be needed.

The following factors related to thrips biology and ecology should be considered when planning thrips management programs:

- Thrips infestations are generally higher on April and early May planted cotton compared with later planting dates.
- Thrips infestations are lower in reduced tillage systems compared with conventionally tilled systems (winter cover crops should be killed at least 3 weeks prior to planting and no green vegetation should be present at planting).
- Seedling injury and potential yield impacts from thrips feeding are compounded by slow seedling growth due to cool temperatures or other plant stresses (i.e. PRE herbicide injury).
- A rapidly growing seedling can better tolerate thrips feeding.
- Seedlings become more tolerant of thrips feeding as they develop; small seedlings (<2-leaf) are more sensitive to thrips injury in terms of yield loss compared with 3-4 leaf seedlings.
- Slow growing seedlings will remain in the thrips "susceptible window" for a more extended time compared with a rapidly growing seedling; it is unlikely that seedlings which have reached the 4-leaf stage and are growing rapidly will benefit from supplemental foliar sprays.

Neonicotinoid seed treatments including imidacloprid or thiamethoxam provide similar levels of thrips control and are active on thrips for 14-21 days after planting. Research and observation have shown that a supplemental foliar spray is often needed in addition to a neonicotinoid seed treatment when thrips infestations are high. We typically expect to see higher thrips infestations on early planted cotton in conventional tillage systems. Unless thorough scouting reveals thrips populations are below established thresholds, **a foliar thrips systemic insecticide should be applied at the 1-leaf stage in conventional tilled fields planted prior to May 10 when a noenicotinoid seed treatment is used**. In most situations this program will provide good thrips control, but the fields should be scouted regularly for thrips and injury following the foliar spray. In fields planted after May 10 or where reduced tillage is used, the risk of high thrips infestations is lower and an automatic foliar spray should not be applied; scout and treat when thresholds are exceeded.

Thrips populations in some areas of the US have shown reduced susceptibility to neonicotinoid seed treatments. However, thrips feeding on seedlings from thiamethoxam-treated seed appears to be more severe than imidacloprid-treated seed in these areas. Surveys of tobacco thrips poulations in Georgia during 2014 indicated that susceptibility to neonicotinoids was variable

meaning that some populations may not be as easily controlled as others. This is a potential problem we will continue to monitor closely.

Aphid Management

Cotton aphid is a consistent and predictable pest of cotton in Georgia. Aphids will typically build to moderate to high numbers and eventually crash due to a naturally occurring fungus. This fungal epizootic typically occurs in late June or early July depending on location. Once the aphid fungus is detected in a field (gray fuzzy aphid cadavers) we would expect the aphid population to crash within a week.

Aphids feed on plant juices and secrete large amounts of "honeydew", a sugary liquid. The loss of moisture and nutrients by the plants has an adverse effect on growth and development. This stress factor can be reduced with the use of an aphid insecticide. However, research conducted in Georgia fails to consistently demonstrate a positive yield response to controlling aphids. Invariably, some fields probably would benefit from controlling aphids during some years. Prior to treatment, be sure there is no indication of the naturally occurring fungus in the field or immediate vicinity. Also consider the levels of stress plants are under, vigorous and healthy plants appear to tolerate more aphid damage than stressed plants.

Tobacco Budworm / Corn Earworm Management

Tobacco budworm and corn earworm comprise the Heliothine complex. Although these two species appear very similar in the egg and larval stages and cause similar damage, they are different insects and their susceptibility to specific insecticides differ. Three generations of tobacco budworm infest cotton each year. The first generation usually occurs in early June, the second in early July, and the last during August. These time periods vary from year to year and locality within the state but generally occur on a four-week cycle. Two generations of corn earworm infest cotton. The first corn earworm infestation is typically observed during mid-July when corn begins to dry down and a second generation occurs approximately four weeks later. Late in the season overlapping generations of both species are often observed.

It is important that we accurately distinguish between these two species. The adult or moth stage of tobacco budworm and corn earworm can be easily distinguished (See ***Cotton Scout Handbook*** for a detailed discussion of insects and scouting techniques). Observation of "flushing" moths during scouting and other field activities provides an opportunity to recognize which is the predominant species. Tobacco budworm and corn earworm larvae can be distinguished upon careful examination with a hand lens or use of a dissecting microscope (see http://www.gaipm.org/cotton/larvaid.html for identification procedures). Populations of tobacco budworm infesting Georgia cotton are resistant to the pyrethroid class of insecticides and therefore **non-pyrethroid insecticides should be used to control tobacco budworm**.

On non-Bt cotton insecticide applications should target larvae 1/4 inch in length or less (less than 3 days of age). Coverage and penetration of the canopy with insecticide sprays are important. These basic principles of insect control are especially important if high populations or difficult to control larvae are present.

Distinguishing tobacco budworm and corn earworm is also important in Bt cotton. Corn earworm is less susceptible to the Bt toxin compared with tobacco budworm. Supplemental insecticide treatments may be needed for corn earworm control on Bt cotton whereas Bt cottons provide excellent control of tobacco budworm.

Pyrethroid Resistant Tobacco Budworm

Tobacco budworm populations in Georgia exhibit moderate to high levels of pyrethroid resistance. Erratic and often unacceptable control would be expected if pyrethroids were used for control of tobacco budworm. In areas where tobacco budworm commonly infests cotton, producers should utilize Bt cotton which has provided excellent control. On non-Bt cotton, pyrethroid insecticides should **not** be used for control of tobacco budworm. Non-pyrethroid insecticides should be used in a timely basis for control of tobacco budworm on non-Bt cotton.

Difficult to Control Corn Earworm

Susceptibility of corn earworm to pyrethroid insecticides has declined in some areas of the US during recent years. Elevated LD50s (the lethal dose to kill 50 percent of a population) of some corn earworm collections have been observed in LA, VA, and TX, as well as Georgia. During recent years, corn earworm susceptibility to pyrethroids has been monitored using cypermethrin (pyrethroid) treated glass vials. To conduct Adult Vial Tests, moths are collected from pheromone traps and placed in pyrethroid treated vials and mortality is evaluated 24 hours later. Since 2000 we have observed a trend for increased survival in pyrethroid treated vials; but this trend is variable. Increased survival suggests that populations will be more difficult to control with a field application of a pyrethroid insecticide. Results of Adult Vial Tests will be reported in the UGA Cotton News (found online at http://ugacotton.com) as needed which is published regularly during the growing season.

Recommendations for control of corn earworm include the use of medium to high rates of pyrethroids for low to moderate infestations. Under heavy pressure, consider adding an ovicide or another larvacide with the pyrethroid. Efficacy of pyrethroid sprays should be evaluated three days after application. If poor control of corn earworm is observed and other factors of poor control (coverage, rate, and timing of application) can be ruled out, a non-pyrethroid insecticide should be used. We cannot predict if this problem will develop further or if, when, or where it may occur.

Bt Cotton Management

Commercially available Bt cotton technologies include Bollgard II , WideStrike, and WideStrike III. Bt cottons are not immune from economic damage from caterpillar pests and have no activity on "bug" pests such as plant bugs and stink bugs. Thus, scouting for insect pests in Bt cotton (both caterpillar and bug pests) continues to be important.

Bollgard II is a two-gene Bt cotton that contains the Cry1Ac and Cry2Ab toxins and WideStrike is a two-gene Bt cotton that contains the Cry1Ac and Cry1F toxins. WideStrike III is a three-gene Bt cotton that contains the Cry1Ac, Cry1F, and Vip3A toxins. Currently available Bt cottons provide excellent control of tobacco budworm and good control of most caterpillar pests. However, supplemental insecticides may be needed for pest such as corn earworm and fall and beet armyworms. Be sure to monitor these cottons for early signs of infestation as the presence of numerous moths, eggs, or small larvae should influence insecticide selection when applications are made for other pests such as stink bugs.

Bt Cotton Resistance Management

Since Bt cotton provides continuous season long activity against tobacco budworm and corn earworm, there is a high potential for one or both of these pests to quickly develop resistance if an effective resistance management plan is not implemented. Resistance management in Bt cotton uses the refuge approach to maintain a pool of susceptible moths to mate with any resistant moths that may survive on Bt cotton. Producers should maintain full knowledge of the details and follow resistance management requirements of use agreements with suppliers of transgenic seed

or technology**.** Weedy host plants and non-cotton agronomic crops currently serve as a natural refuge for Bollgard II and WideStrike cottons.

Stink Bug Management

The pest status of stink bugs in Georgia cotton and other areas of the Southeast have been elevated in recent years due to the reduction of broad spectrum insecticide use. Eradication of the boll weevil, greater utilization of natural controls, commercialization of Bt transgenic cotton, and development of caterpillar specific insecticides have all contributed to the reduced use of broad spectrum insecticides. Routine use of broad spectrum insecticides, such as pyrethroids to control other pests in years past suppressed stink bugs below economic levels. In the absence of coincidental control of stink bugs, populations can build to damaging levels.

The most important species of stink bugs that we observe in Georgia are the southern green and brown stink bugs. Southern green is generally the most common. Organophosphate insecticides such as Bidrin provide excellent control of southern green and brown stink bugs. Pyrethroids provide good control of southern green stink bugs and are useful when populations of both caterpillar pests and stink bugs infest the same field. Research indicates that the brown stink bug is less susceptible to pyrethroids compared with southern green stink bug (control of brown stink bugs with pyrethroids increases when high rates are used). If brown stink bugs are present at economic levels an organophosphate insecticide should be used. However, the key to successful management of stink bugs in cotton is to know when and if an insecticide application is needed.

Stink bugs have piercing sucking mouthparts and damage cotton by feeding on the seeds of developing bolls. Stink bugs feed by piercing the boll wall with their beak and injecting a digestive enzyme into the boll in or near the seed to soften or dissolve plant tissues so the bug can remove them. In addition to physical damage, this process allows for entry of rot organisms that contributes to degradation of bolls reducing yield and quality. Bolls damaged by stink bugs may show sunken, purple spots on the outside boll wall; however this is not a reliable indicator of stink bug damage. Internal symptoms of injury are a much better indicator of stink bug feeding and include stained or yellowish lint and/or callous growths or warts on the inner surface of the boll wall where the stink bug penetrated the boll. The wart or callous growth on the inner surface of the boll wall will form within 48 hrs on developing bolls. As bolls mature and open, damage often appears as matted or tight locks with localized discoloration that will not fluff. Severely damaged bolls may not open at all.

Scouting for stink bugs should be a priority as plants begin to set bolls. In addition to being observant for nymphs and adult stink bugs, scouts should assess stink bug populations by quantifying the percentage of bolls with internal damage. Estimating boll injury has proven to be a reliable technique for timing insecticide applications when needed. Bolls are considered injured if stained lint is observed or a warty growth is present on the inner surface of the boll wall. Bolls approximately the diameter of a quarter should be examined. Bolls of this age are preferred feeding sites for stink bugs can be easily squashed between your thumb and forefinger. It is important that bolls of this size (soft) are selected. If bolls which are the diameter of a quarter are not present, i.e. the first or second week of bloom, sample the largest bolls present. Monitor boll retention during the first week of bloom; if small bolls are damaged by stink bugs they will often be aborted (small bolls which are damaged by stink bugs will often have “jelly-like” contents in some locules). In addition to stink bugs, other bug species such as tarnished plant bug and leaf-footed bugs may injure developing bolls.

The number of bolls per plant which are susceptible to stink bugs is not constant and varies during the year. The greatest number of susceptible bolls per plant generally occurs during weeks 3-5 of bloom. During early bloom there are relatively few bolls present. During late bloom, many bolls are present but only a limited number may be susceptible to stink bug damage (individual bolls are susceptible to stink bugs in terms of yield loss until approximately 25 days of age). A **dynamic threshold** which varies by the number of stink bug susceptible bolls present is recommended for determining when insecticide applications should be applied for boll feeding bugs.

The boll injury threshold for stink bugs should be adjusted up or down based on the number of susceptible bolls present. Use a 10-15% boll injury threshold during weeks 3-5 of bloom (numerous susceptible bolls present), 20% during weeks 2 and 6, and 30%(+) during weeks 7(+) of bloom (fewer susceptible bolls present). Environmental factors such as drought and/or other plant stresses may cause susceptible boll distribution to vary when normal crop growth and development is impacted; thresholds should be adjusted accordingly. Detection of 1 stink bug per 6 feet of row would also justify treatment.

Week of bloom	Stink Bug Threshold (% Damage)
1	Retention
2	20
3	10-15
4	10-15
5	10-15
6	20
7+	30+

Research suggests that in addition to yield loss, excessive stink bug damage can reduce fiber quality characteristics. Fiber characteristics associated with length, maturity, and color are reduced when excessive stink bug damage is present.

Stink bugs are a primary pest of Georgia cotton and require management. Not all fields will require treatment, but for profit maximization scouting and treating on an as-needed basis is required. Fields at highest risk for stink bug infestations are those that have not received a broad spectrum insecticide during the past two weeks. Stink bug infestations are often first observed near field edges (especially near a peanut planting). Some innovative growers have chosen to scout and treat cotton near field edges independent of the entire field.

Boll Weevil Eradication Program

The BWEP is in the containment phase. Activities include reduced trapping but active spraying in areas where boll weevils are detected. Boll weevils are the responsibility of the program, so growers with suspected boll weevil problems should notify their local field supervisors. Everyone growing cotton is required to pay a per bale assessment for the BWEP. Boll weevil traps will be placed in fields by late July and monitored every three weeks for reinfestation. It is vitally important that traps are standing and functional. If a trap is accidentally knocked down or destroyed, stand it back up or contact your local field supervisor. All attempts to prevent reinfestations should be taken. A common means for boll weevils to reenter Georgia is on used farm machinery such as pickers and module trucks. If you plan to acquire machinery from a non-eradicated area, be sure it is boll weevil free. Contact the BWEP for more details.

COTTON: *COTTON INSECT CONTROL*

PEST	INSECTICIDE	IRAC GROUP	FORMULATION PER ACRE	LBS. ACTIVE PER ACRE	REI*/PHI* Hours (H) or Days(D)	REMARKS
Aphid (Cotton)	*acetamiprid* Assail 30SG	4A	1.5-2.5 ozs	0.028-0.047	12(H) / 28(D)	Apply when aphids are abundant and seedling leaves are severely curled, or when "honeydew" is present in older cotton. A naturally occurring fungal disease often eliminates the need for sprays, but this epidemic occurs only after aphid populations reach high levels and tends to be less effective late in the season.
	dicrotophos Bidrin 8	1B	4.0-8.0 ozs	0.25-0.50	6(D) / 30(D)	
	flonicamid Carbine 50WG	9C	1.4-2.8 ozs	0.044-0.088	12(H) / 30(D)	
	imidacloprid Admire Pro 4.6	4A	0.9-1.7 ozs	0.032-0.061	12(H) / 14(D)	
	sulfoxaflor Transform 50 WG	4C	0.75-1.0 oz	0.023-0.031	24(H) / 14(D)	
	thiamethoxam Centric 40 WG	4A	1.25-2.0 ozs	0.031-0.05	12(H) / 21(D)	
Beet Armyworm	*emamectin benzoate* Denim 0.16	6	6-8 ozs	0.0075-0.01	12(H) / 21(D)	Apply when 10% of squares, or terminals are damaged, 10% of blooms are damaged and/or infested, or when 10 active "hits" are observed per 300 row feet. Beet armyworms may infest Palmer amaranth and move to cotton as larvae develop; Bt cottons will not control large beet armyworms moving from Palmer amaranth.
	diflubenzuron Dimilin 2L	15	4-8 ozs	0.0625-0.125	12(H) / 14(D)	
	flubendiamide Belt 4SC	28	2-3 ozs	0.0625-0.094	12(H) / 28(D)	
	indoxacarb Steward 1.25EC	22	9.2-11.3 ozs	0.09-0.11	12(H) / 14(D)	
	methoxyfenozide Intrepid 2F	18	4 ozs	0.0625	4(H) / 14(D)	
	novaluron Diamond 0.83EC	15	6-12 ozs	0.039-0.077	12(H) / 30(D)	
	chlorantraniliprole Prevathon 0.43	28	14-27 ozs	0.047-0.09	4(H) / 21(D)	
	spinosad Blackhawk	5	2.4-3.2 ozs	0.054-0.072	4(H) / 28(D)	
Bollworm/ Tobacco Budworm	**NON-PYRETHROIDS**					On non-Bt cotton apply when 8 small larvae are found per 100 terminals prior to first insecticide treatment, or when 5 larvae are found after first spray. Due to the threat of pyrethroid resistance, non-pyrethroid insecticides are recommended for control of tobacco budworm. Resistance management: Do not treat successive generations with insecticides that have the same mode of action. Bt Cotton containing the Bollgard II or WideStrike Bt genes are effective tools for use in bollworm and tobacco budworm management programs. Apply insecticide on Bt cotton when 8 larvae (1/4 inch or greater in length) are found per 100 plants.
	emamectin benzoate Denim 0.16	6	8-12 ozs	0.01-0.015	12(H) / 21(D)	
	flubendiamide Belt 4SC	28	2-3 ozs	0.063-0.094	12(H) / 28(D)	
	indoxacarb Steward 1.25EC	22	11.3 ozs	0.11	12(H) / 14(D)	
	methomyl Lannate LV 2.4	1A	1.5-2 pts	0.45-0.6	72(H) / 15(D)	
	profenofos Curacron 8E	1B	0.75-1 pt	0.75-1.0	48(H) / 30(D)	

COTTON INSECT CONTROL

PEST	INSECTICIDE	IRAC GROUP	FORMULATION PER ACRE	LBS. ACTIVE PER ACRE	REI*/PHI* Hours (H) or Days(D)	REMARKS
Bollworm/ Tobacco Budworm (continued)	**NON-PYRETHROIDS**					
	chlorantraniliprole Prevathon 0.43	28	14-27 ozs	0.047-0.09	4(H) / 21(D)	
	spinosad Blackhawk	5	2.4-3.2 ozs	0.054-0.072	4(H) / 28(D)	
	PYRETHROIDS					
	alpha-cypermethrin Fastac 0.83	3A	2.6-3.6 ozs	0.017-0.023	12(H) / 14(D)	Tobacco budworm is resistant to pyrethroid insecticides. Pyrethroids should not be used for control of tobacco budworm.
	beta-cyfluthrin Baythroid XL 1	3A	1.6-2.6 ozs	0.0125-0.02	12(H) / 0(D)	
	bifenthrin Brigade 2EC Discipline 2EC Fanfare 2EC	3A	2.6-6.4 ozs 2.6-6.4 ozs 2.6-6.4 ozs	0.04-0.1 0.04-0.1 0.04-0.1	12(H) / 14(D)	
	cypermethrin Ammo 2.5EC Up-Cyde 2.5EC	3A	2-5 ozs 2-5 ozs	0.04-0.1 0.04-0.1	12(H) / 14(D)	
	esfenvalerate Asana XL 0.66	3A	5.8-9.6 ozs	0.03-0.0495	12(H) / 21(D)	
	gamma-cyhalothrin Prolex 1.25 Declare 1.25	3A	1.28-2.05 ozs 1.28-2.05 ozs	0.0125-0.02 0.0125-0.02	24(H) / 21(D)	
	lambda-cyhalothrin Karate w/ Zeon 2.08 Karate EC 1 Silencer 1	3A	1.6-2.56 ozs 3.2-5.12 ozs 3.2-5.12 ozs	0.025-0.04 0.025-0.04 0.025-0.04	24(H) / 21(D)	
	zeta-cypermethrin Mustang Max 0.8	3A	2.64-3.6 ozs	0.0165-0.0225	12(H) / 14(D)	
Bollworm/Tobacco Budworm (ovicides)	*methomyl* Lannate LV 2.4	1A	0.4-0.75 pt	0.12-0.22	72(H) / 15(D)	Apply in a tank-mix with a larvacide when large numbers of eggs are present.
	profenofos Curacron 8E	1B	0.125-0.25 pt	0.125-0.25	48(H) / 30(D)	
Cutworm (seedling cotton)	*acephate* Orthene 97 Orthene 90S Acephate 97 Acephate 90	1B	0.75 lb 0.80 lb 0.75 lb 0.80 lb	0.72 0.72 0.72 0.72	24(H) / 21(D)	Apply when stand is threatened. Spot treatment is often adequate. Pyrethroids provide good control of cutworms at low rates. See insecticide label for use rate.
	chlorpyrifos Lorsban 4E Chlorpyrifos 4E	1B	1.5-2 pts 1.5-2 pts	0.75-1.0 0.75-1.0	24(H) / 14(D)	
	Pyrethroids	3A	see remarks			

COTTON INSECT CONTROL

PEST	INSECTICIDE	IRAC GROUP	FORMULATION PER ACRE	LBS. ACTIVE PER ACRE	REI*/PHI* Hours (H) or Days(D)	REMARKS
Fall Armyworm	*chlorantraniliprole* Prevathon 0.43	28	14-27 ozs	0.047-0.09	4(H) / 21(D)	Apply when 15 larvae are found per 100 plants. Control of large larvae (›½ inch in length) is difficult; higher rates should be used.
	diflubenzuron Dimilin 2L	15	4-8 ozs	0.0625-0.125	12(H) / 14(D)	
	emamectin benzoate Denim 0.16	6	8-12 ozs	0.01-0.015	12(H) / 21(D)	
	flubendiamide Belt 4SC	28	2-3 ozs	0.0625-0.094	12(H) / 28(D)	
	indoxacarb Steward 1.25EC	22	9.2-11.3 ozs	0.09-0.11	12(H) / 14(D)	
	methomyl Lannate LV 2.4	1A	1.5-2 pts	0.45-0.6	72(H) / 15(D)	
	methoxyfenozide Intrepid 2F	18	4-10 ozs	0.0625-0.156	4(H) / 14(D)	
	novaluron Diamond 0.83EC	15	6-12 ozs	0.039-0.077	12(H) / 30(D)	
	profenofos Curacron 8E	1B	0.75-1.0 pt	0.75-1.0	48(H) / 30(D)	
	Pyrethroid	3A	See remark			Pyrethroids at high rates provide good suppression of larvae less than 1/8 inch in length.
	spinosad Blackhawk	5	2.4-3.2 ozs	0.054-0.072	4(H) / 28(D)	
Plant Bugs and Fleahoppers	*acephate* Orthene 97 Orthene 90S Acephate 97 Acephate 90	1B	 0.25-0.50 lb 0.25-0.50 lb 0.25-0.50 lb 0.25-0.50 lb	 0.24-0.49 0.225-0.45 0.24-0.49 0.225-0.45	24(H) / 21(D)	Apply insecticide when plants are retaining less than 80% of pinhead squares and numerous plant bugs are observed. Sweep nets and drop cloths may also be used to monitor plant bugs. Sweep nets (15 inch in diameter) are an effective tool for monitoring adult plant bug populations. Drop cloths are more effective for monitoring immatures. Thresholds: First 2 weeks of squaring: Sweep Net: 8 plant bugs per 100 sweeps. Drop Cloth: 1 plant bug per 6 row feet. Third week of squaring through bloom: Sweep Net: 8 plant bugs per 100 sweeps. Drop Cloth: 1 plant bug per 6 row feet. Diamond is an insect growth regulator and will not control adults.
	dicrotophos Bidrin 8	1B	4-8 ozs	0.25-0.5	6(D) / 30(D)	
	imidacloprid Admire Pro 4.6	4A	0.9-1.7 ozs	0.032-0.061	12(H) / 14(D)	
	novaluron Diamond 0.83EC	15	9-12 ozs	0.058-0.077	12(H) / 30(D)	
	oxamyl Vydate C-LV 3.77	1A	8.5-17 ozs	0.25-0.50	48(H) / 14(D)	
	sulfoxaflor Transform 50 WG	4C	1.5-2.25 ozs	0.047-0.071	24(H) / 14(D)	
	thiamethoxam Centric 40 WG	4A	2 ozs	0.05	12(H) / 21(D)	

COTTON INSECT CONTROL

PEST	INSECTICIDE	IRAC GROUP	FORMULATION PER ACRE	LBS. ACTIVE PER ACRE	REI*/PHI* Hours (H) or Days(D)	REMARKS
Soybean Looper	*emamectin benzoate* Denim 0.16	6	8-12 ozs	0.01-0.015	12(H) / 21(D)	Treatment is necessary when soybean loopers threaten to defoliate cotton with immature bolls.
	flubendiamide Belt 4SC	28	2-3 ozs	0.0625-0.094	12(H) / 28(D)	
	indoxacarb Steward 1.25EC	22	6.7-9.2 ozs	0.065-0.09	12(H) / 14(D)	
	methoxyfenozide Intrepid 2F	18	4-10 ozs	0.0625-0.156	4(H) / 14(D)	
	novaluron Diamond 0.83EC	15	6-12 ozs	0.039-0.077	12(H) / 30(D)	
	spinosad Blackhawk	5	2.4-3.2 ozs	0.054-0.072	4(H) / 28(D)	
Spider Mites	*abamectin* Agri-Mek 0.15	6	8-16 ozs	0.009-0.018	12(H) / 20(D)	Apply when mites are spreading. Spot treatment may be adequate. Thorough coverage is essential; a second application may be necessary. In fields where mites are observed, conservation of beneficial insects should be a priority; insecticides prone to flare mites should be avoided when targeting other pests. *Bifenthrin only provides suppression of mites.
	*bifenthrin** Brigade 2EC Discipline 2EC Fanfare 2EC	3A	 6.4 ozs 6.4 ozs 6.4 ozs	 0.1 0.1 0.1	12(H) / 14(D)	
	etoxazole Zeal 72 WSP	10B	0.66-1.0 oz	0.03-0.045	12(H) / 28(D)	
	fepyroximate Portal 0.4	21A	16-32 ozs	0.05-0.1	12(H) / 14(D)	
	propargite Comite II 6	12C	1.25-2.25 pts	0.937-1.687	6(D) / 50(D)	
	profenofos Curacron 8E	1B	0.5-0.75 pt	0.5-0.75	48(H) / 30(D)	
	spiromesifen Oberon 2SC	23	8-16 ozs	0.125-0.25	12(H) / 30(D)	
Stink Bugs	**ORGANOPHOSPHATES**					The boll injury threshold should be adjusted up or down based on the number of susceptible bolls present. Use a 10-15% boll injury threshold during weeks 3-5 of bloom (numerous susceptible bolls present), 20% during weeks 2 and 6, and 30%(+) during weeks 7(+) of bloom (fewer susceptible bolls present). Detection of 1 stink bug per 6 row feet would also justify treatment. Higher stink bug populations are typically observed on late planted cotton compared with early planted cotton. Organophosphates should be used for control of brown stink bugs.
	acephate Orthene 97 Orthene 90S Acephate 97 Acephate 90	1B	 0.75 lb 0.8 lb 0.75 lb 0.8 lb	 0.72 0.72 0.72 0.72	24(H) / 21(D)	
	dicrotophos Bidrin 8	1B	4-8 ozs	0.25-0.5	6(D) / 30(D)	
	PYRETHROIDS					
	alpha-cypermethrin Fastac 0.83	3A	2.6-3.6 ozs	0.017-0.023	12(H) / 14(D)	

PEST	INSECTICIDE	IRAC GROUP	FORMULATION PER ACRE	LBS. ACTIVE PER ACRE	REI*/PHI* Hours (H) or Days(D)	REMARKS
Stink Bugs (continued)	**PYRETHROIDS**					
	beta-cyfluthrin Baythroid XL 1	3A	1.6-2.6 ozs	0.0125-0.0205	12(H) / 0(D)	
	bifenthrin Brigade 2EC	3A	2.6-6.4 ozs	0.04-0.1	12(H) / 14(D)	
	Discipline 2EC		2.6-6.4 ozs	0.04-0.1		
	Fanfare 2EC		2.6-6.4 ozs	0.04-0.1		
	esfenvalerate Asana XL 0.66	3A	5.8-9.6 ozs	0.03-0.0495	12(H) / 21(D)	
	gamma-cyhalothrin Prolex 1.25	3A	1.28-2.05 ozs	0.0125-0.02	24(H) / 21(D)	
	Declare 1.25		1.28-2.05 ozs	0.0125-0.02		
	lambda-cyhalothrin Karate w/ Zeon 2.08	3A	1.6-2.56 ozs	0.025-0.04	24(H) / 21(D)	
	Karate EC 1		3.2-5.12 ozs	0.025-0.04		
	Silencer 1		3.2-5.12 ozs	0.025-0.04		
	zeta-cypermethrin Mustang Max 0.8	3A	2.64-3.6 ozs	0.0165-0.0225	12(H) / 14(D)	
Thrips (seedling cotton), At-Plant Treatments	*acephate* Orthene 97ST	1B	Commercial seed	treatment	24(H) / 21(D)	
	Orthene 97		1.0 lb	0.97		
	Orthene 90S		1.1 lb	1.0		
	Acephate 97		1.0 lb	0.97		Apply acephate as an in-furrow spray during planting.
	Acephate 90		1.1 lb	1.0		
	imidacloprid Admire Pro4.6	4A	9.2 ozs	0.33	12(H) / 14(D)	Apply Admire Pro as an in-furrow spray during planting directed on or below seed.
	thiamethoxam Cruiser	4A	Commercial seed	treatment	12(H) / na	Thrips populations in some areas of the US have shown reduced susceptibility to neonicotinoid seed treatments (IRAC Group 4A). Neonicotinoid seed treatments are active for 14-21 days but may need a supplemental foliar insecticide application if thrips populations are high.
	imidacloprid Gaucho 600	4A	Commercial seed	treatment	12(H) / na	
Thrips (seedling cotton), Foliar Spray	*acephate* Orthene 97	1B	3.0 ozs	0.18	24(H) / 21(D)	Apply insecticide when 2-3 thrips per plant are counted and immatures are present. Expect higher thrips populations on early planted cotton. Thrips injury is more severe when seedlings are not growing rapidly (i.e. stress from cool temperatures or PRE herbicides). Rapidly growing seedlings can better tolerate thrips feeding.
	Orthene 90S		3.2 ozs	0.18		
	Acephate 97		3.0 ozs	0.18		
	Acephate 90		3.2 ozs	0.18		
	dicrotophos Bidrin 8	1B	1.6-3.2 ozs	0.1-0.2	6(D) / 30(D)	Treatment is rarely necessary after plants have 4 true leaves and are growing vigorously.

COTTON INSECT CONTROL

PEST	INSECTICIDE	IRAC GROUP	FORMULATION PER ACRE	LBS. ACTIVE PER ACRE	REI*/PHI* Hours (H) or Days(D)	REMARKS
Thrips (seedling cotton), Foliar Spray (continued)	*dimethoate* Dimethoate 4	1B	0.25-0.5 pt	0.125-0.25	48(H) / 14(D)	
Whitefly (banded winged)	*acephate* Orthene 97	1B	0.5-1.0 lb	0.49-0.97	24(H) / 21(D)	Apply when 50% of terminals in rapidly growing cotton are infested, or when honeydew is found on foliage or lint of older cotton with open bolls.
	Orthene 90S		0.5-1.0 lb	0.45-0.90		
	Acephate 97		0.5-1.0 lb	0.49-0.97		
	Acephate 90		0.5-1.0 lb	0.45-0.90		
	thiamethoxam Centric 40 WG	4A	2 ozs	0.05	12(H) / 21(D)	
Whitefly (silverleaf)	*acetamiprid* Assail 30 SG	4A	4.0-5.3 ozs	0.075-0.1	12(H) / 28(D)	Silverleaf whitefly is difficult to control with insecticides. Early detection and conservation of natural controls are important. Hairy leaf cottons are preferred by silverleaf whiteflies compared with smooth leaf varieties. Silverleaf whitefly infestations are typically higher on late planted cotton.
	dinotefuron Venom 70WDG	4A	1-3 ozs	0.045-0.134	12(H) / 14(D)	
	pyriproxyfen Knack 0.86	7D	8 ozs 5 ozs fb 5 ozs	0.05375 0.033 fb 0.033	12(H) / 28(D)	Vegetative cotton; 5 ozs. followed by 5 ozs.. See Label.
	spiromesifin Oberon 2	23	8-16 ozs	0.125-0.25	12(H) / 30(D)	Bifenthrin applied at high rates will suppress adults; tank-mixing with acephate may improve control.
	buprofezin Courier 40SC	16	9-12.5 ozs	0.25-0.35	12(H) / 14(D)	

Premixed or Co-Packed Insecticide Products:

Products listed below are available as premixes or co-packages of two insecticidal active ingredients. When using premixed or co-packaged products, be sure the use of all active ingredients is necessary. Unnecessary applications or use of reduced rates of an active ingredient may lead to or intensify insecticide resistance.

bifenthrin, avermectin B1 (Athena)
bifenthrin, imidacloprid (Brigadier)
dicrotophos, bifenthrin (Bidrin XP II)
flubendiomide, buprofezin (Tourismo)
imidacloprid, cyfluthrin (Leverage)
lambda-cyhalothrin, chlorantraniliprole (Besiege)
lambda-cyhalothrin, thiamethoxam (Endigo)
spinosad, gamma-cyhalothrin (Consero)
zeta-cypermethrin, bifenthrin (Hero)
chlorpyrifos, lambda-cyhalothrin (Cobalt Advanced)
zeta-cypermethrin, chlorpyrifos (Stallion)

COTTON DISEASE AND NEMATODE MANAGEMENT

What to consider carefully in preparation for the 2015 season:

- **Management of nematodes: use of resistant varieties, e.g., PHY 427 WRF, DP 1454NR B2RF and ST 4946 GLB2 for use where southern root-knot nematode is a problem.**
- **Management of nematodes: fumigation with Telone II, "risk management of zones", and "site specific" applications.**
- **Management of nematodes: seed treatment nematicides and Vydate CLV; too early to know if other products (e.g., Velum Total or Counter 20G) will be labeled in Georgia.**
- **Fusarium wilt: this disease causes significant losses in some fields; management options include crop rotation and management of nematodes. But is this enough?**
- **STAY TUNED: questions remain as to availability of Velum Total from bayer CropScience or Counter 20G for nematode management n 2015……**

Diseases and nematodes affecting cotton continue to gain increased awareness from growers. This is, in part, the result of loss of a product like Temik 15G and registration of fungicides like Headline and Quadris for management of leaf diseases. Such bring greater awareness of nematodes and diseases that affect the cotton crop. Release of root-knot nematode resistant varieties has also increased grower awareness as these varieties necessitate further decisions in best management practices for Georgia's cotton growers.

Abundant rainfall early in 2013 increased outbreaks of seedling diseases, Fusarium wilt and Ascochyta wet weather blight. Stemphylium leaf spot was commonly observed later in the season, as was target spot. A significant number of fields were treated with fungicides to protect against target spot. Plant-parasitic nematodes, especially the southern root-knot nematode and the reniform nematode, affected production in many fields. Growers continue to look for solutions to manage nematodes after the loss of Temik 15G.

Issues that cotton growers need to be most aware of in 2015 include:

1. Management of plant-parasitic nematodes by integration of resistant varieties, crop rotation, and use of nematicides. Of particular concern/interest will be which nematicides will be available and the integration of nematicides with nematode-resistant varieties.
2. Grower-implementation of risk-management zones and site-specific applications of nematicides (especially Telone II) to manage nematodes.
3. Target spot of cotton- determination of risk and appropriate use of fungicides for management.
4. Greater awareness of the symptoms, impact and management of Fusarium wilt.

<u>Note 1 for 2015- Target Spot:</u>
Because conditions were dry during the growing 2014 growing season, target spot was not as widespread of a problem for growers as it has been in recent year. Still, in field trials use of fungicides did reduce severity of disease and increase yields. Also, yield response with the use of fungicides was observed for multiple varieties.

The most obvious symptoms associated with foliar diseases of cotton are spots and defoliation. The spots on the leaves likely decrease the ability of the leaf to produce the sugars that feed the growing plant and the developing bolls. Premature defoliation (loss of leaves) of the cotton plant may result in one of several scenarios.

First, if only older leaves lower in the canopy are lost, then the defoliation is unlikely to have a negative impact on yield. Older leaves generally are not productive and loss of a limited number of leaves may actually increase airflow and decrease humidity in the canopy.

Second, if premature defoliation extends upward in the canopy and results in loss of active, productive leaves, then yield may be affected. The subtending leaf associated with a boll is important for development of that boll. If such leaves are lost, then young bolls may be aborted or development negatively affected.

Third, if premature defoliation extends to the top of the plant, then the youngest bolls are unlikely to fully develop and open. For these and other reasons, it is important to promote healty leaves and a healthy canopy of foliage.**IF YOU REMEMBER NOTHING ELSE ABOUT TARGET SPOT:**

1. **Target spot causes significant premature defoliation of the cotton crop.**
2. **Target spot is common in cotton in the southeastern United States.**
3. **Fungicides (Headline, Quadris and Twinline) can significantly reduce premature defoliation resulting from target spot, but typically not Stemphylium leaf spot.**
4. **Based upon trial results, timings of applications that most consistently reduce premature defoliation are those that are made during the first and third weeks of bloom; the third week of bloom seems especially critical.**
5. **No fungicide program yet assessed in Georgia has effectively eliminated premature defoliation when disease is severe.**
6. **In our studies, there has been tremendous variability in yield associated with use of fungicides to protect against target spot. It is not uncommon to find little or no yield increase associated with the use of fungicides; however in other cases (typically the most severe) numeric increases of as much as 200 lb/A lint are observed.**
7. **Fungicides are an important and valuable tool in the management of target spot; however they are not needed in every field where target spot is observed. Presented at the conclusion of this section is a draft of Risk Index for Target Spot to aide growers in determining where best to use a fungicide.**

Where abundant rainfall (or irrigation) and warm temperatures occur during a season, a significant portion of the cotton crop across the Coastal Plain may be affected by target spot. In mild cases the diseased spots are a curiosity; in severe cases up to 80% defoliation may occur across large areas of a field. Target spot may affect all varieties of cotton grown in Georgia, though some may be affected more than others. Excessive cotton growth where periods of leaf wetness are extended is most often associated with outbreaks of target spot.

Rainfall and irrigation help to spread target spot in at least two ways.
First, rain-splash helps to move spores of the target spot pathogen from debris on the soil to lower leaves of the cotton plant, where infection occurs leading to production of leaf spots.
Second, rainfall and irrigation provide the moisture needed for spore germination and infection to occur. Moisture is also important for the production of spores on the spots and for their dispersal and infection of new tissue.

Rainfall and irrigation are critical for the production of cotton in Georgia; however anything that increases periods of leaf wetness, to include dew, will facilitate the development of target spot.

Although management of leaf spot diseases will be discussed elsewhere, below are factors that UGA Cooperative Extension believes increases the risk of a cotton crop to target spot. As risk to target spot increases, the potential benefits to use of a fungicide to protect yield also increase.

Factors that are likely increase risk to target spot of cotton. (See also draft "Risk Index for Target Spot" at conclusion of the Cotton Disease and Nematode Management section):

1. Cotton planted in short rotation, especially in fields where target spot has been a problem in the past.
2. Rank growth in the field, either because of management of other factor, e.g., variety.
3. Field receives overhead irrigation.
4. Abundant rainfall in a growing season coupled with warm temperatures.

Other factors that may contribute to increased risk to target spot include variety selection (research is being conducted now to assess such) and reduced tillage systems (that may allow spores of the fungal pathogen to survive in the crop debris).

Factors to consider for use of fungicides for the management of target spot:

1. The "final" fungicide program has not been established for the management of target spot; however an effective program will include 1-2 applications of Headline, Quadris or Twinline.
2. Timing of the first spray will vary based upon weather conditions during a season; however considerations for timing will include:
    a. Increased risk to the disease (as assessed above).
    b. Detection of small amounts of disease in the field, before the disease has become established and certainly before significant defoliation has occurred. (Note: Best management for any plant disease is achieved by protecting the crop BEFORE disease is established in the field. Because we still have much to learn about target spot and because there are many fields that may not respond to use of fungicides, growers may choose to wait to see if the disease can be found in their field. Such a "wait-and-see" strategy requires careful scouting to assure success.)
    c. Initiation of the fungicide program before the canopy of cotton foliage closes in order to allow for appropriate coverage of the leaves.

3. Current recommendation for initiating a fungicide application on cotton for target spot is when the crop is between 1 and 3 weeks after first bloom. Depending on conditions, e.g., wetter or drier, the optimal time for beginning a program could change.
4. Growers should begin to assess the need for a second application of fungicide no earlier than 3 weeks after the first application.
5. It is currently unclear if some varieties of cotton are more susceptible to target spot than are other varieties; however work continues to answer this important question. **Regardless of variety, the severity of target spot can be minimized by managing cotton growth with PGRs to eliminate rank growth.**

Below are questions commonly asked about leaf spots on cotton:

Question 1. What is causing the leaf spots in Georgia's cotton fields?

Answer 1. There are two factors associated with outbreaks of leaf spots. First is the potassium nutrition in the cotton plant. Insufficient potassium leads to weakened cell walls in the leaves that are more easily breached by fungal pathogens. Insufficient potassium in the cotton crop may be the result of poor soil fertility, or leaching from the soil during periods of heavy rainfall, or during periods of drought when nutrients are not adequately moved into the plant. The second factor, extended periods of wet weather, created conditions favorable for development and spread of fungal diseases, abundant moisture aids in fungal growth and rain-splash and blowing rain aid in spread of disease. From 2014, a dryer-than-normal season may reduce severity of target spot.

Leaf spots found in Georgia's cotton fields include:

A. Stemphylium leaf spot (most common by far, is linked to nutrient deficiencies)
B. Alternaria leaf spot (fairly common, sister disease to Stemphylium leaf spot, is linked to nutrient deficiencies)
C. Cercospora leaf spot (fairly common, is linked to stress and nutrient deficiencies)
D. Target spot/Corynespora leaf spot (newly identified in Georgia, aggressive in 2009, 2010, 2012 and 2013, less important in 2011 and 2014 because of drought) is unrelated to nutrient deficiencies.
E. Ascochyta wet weather blight (not commonly observed but widespread early in 2013 because of abundant rainfall).
F. Angular leaf spot, caused by a bacterial pathogen, was observed in some fields in 2011in 2012 but was not of significant importance. **(Angular leaf spot was diagnosed only once in Georgia in 2014.)**

Question 2. Will disease (especially *Corynespora cassicola* (target spot) and *Stemphylium* sp.) that develops in one season predispose the same field to problems next season?

Answer 2. Although the spores of these fungal pathogens will likely survive until next season amongst the leaf litter and debris, I don't feel that this inoculum will greatly increase chances of severe outbreak of Stemphylium leaf spot from year to year. The deciding factor for this disease will be the weather that occurs in 2015. The drought during the 2014 season decreased the risk to target spot but may have increased the risk to Stepmphylium leaf spot. Outbreaks of Stemphylium leaf spot are historically more common in some fields than in others and in some regions of the state than in other regions. This is likely due to the relationship between potassium levels in the plant, soil type and weather patterns

The spores of *Corynespora cssiicola* (target spot) that survive between seasons could lead to more severe infections in fields where a) the disease was a problem in the past, b) the field is planted using reduced/conservation tillage, c) cotton is planted behind cotton in rotation, and d) weather conditions include frequent rain events.

Bottom line: If our fields experience frequent rains and rank growth (target spot) or if potassium levels are low in the cotton plants (Stemphylium leaf spot), we will likely see another severe outbreak of one or both of these diseases.

Question 3. What is the impact of the spots that affect the leaves to the bracts and the bolls?

Answer 3. Three of the pathogens linked to leaf spots (e.g. *Stemphylium*, *Alternaria*, and *Cercospora*) are NOT boll rot pathogens and at best create superficial blemishes on the cotton bolls. However, under the right conditions (i.e. high rainfall or canopy moisture) it is possible that these superficial wounds could be colonized and exploited by more aggressive pathogens resulting in boll rot. The fourth pathogen, *Corynespora cassiicola*, has been linked to boll rots elsewhere in the world. The fifth, the bacterial pathogen *Xanthomonas campestris* pv *malvacearum*, was found to cause boll rots in Turner and Ben Hill Counties in 2010.

Question 4. How can Headline, Twinline or Quadris best be used to control foliar diseases we have now find in cotton fields? Is tebuconazole effective for management of target spot?

Answer 4. Strobilurin fungicides like Headline and Quadris and Twinline (a pre-mix of pyraclostrobin and metconazole) are fungicides that can be used to manage **target spot**. Appropriate use of these fungicides can reduce the severity of leaf spots, reduce severity of premature defoliation, and protect yields. We continue to assess the use of each of these fungicides. Although tebuconazole can be legally applied to cotton, tebuconazole does not seem to be as effective against target spot as compared to the other labeled fungicides.

It is unclear whether a fungicide, no matter how good a fungicide, can have a significant impact on a disease whose cause is an underlying nutritional problem (Stemphylium, Cercospora, and Alternaria leaf spot diseases). Also, even if a fungicide is effective to one degree or another, it MUST be in place to protect the crop before the disease becomes widespread in a field.

Therefore, growers should consider the following:

A. If disease that is linked to a nutritional problem, such as Stemphylium leaf spot, occurs in a field, a fungicide is unlikely to provide effective control.
B. In the case of target spot/Corynespora leaf spot, there is data to demonstrate that a fungicide treatment can reduce disease and defoliation and also increase yields. This is, obviously, most likely the case where the severity of target spot/Corynespora leaf spot is severe. Corynespora leaf spot is likely to be most severe during periods of extended wet weather.
C. If a grower wants to test the efficacy of a fungicide, I STRONGLY advise leaving untreated areas in the field with which to compare disease control and yield to areas that have been treated.
D. If a grower wants to test efficacy, he should make a fungicide application BEFORE disease becomes established in the field and be prepared to follow with additional applications within 2-3 weeks after initial application.
E. Once disease becomes widespread in the field, it is unlikely that a fungicide would have any efficacy at all and the grower would be better served to save this money and use it elsewhere.

Question 5. What about applying a foliar fertilizer to improve nutrition in the leaves in order to control disease?

Answer 5. I will let our soil scientist address this; however I believe that IF a foliar application of fertilizer could ELIMINATE or greatly reduce the nutritional deficit before disease occurs, then it might be a viable management strategy. Otherwise, the foliar fertilizer would likely have no benefit in disease control.

Note 2 for 2015- Nematode management:

Management of nematodes affecting the cotton crop remains critically important and has been made even more difficult with the loss of Temik 15G. In 2015, growers will have varieties with resistance to the root-knot nematode, nematicides and the opportunity for site-specific applications of Telone II with which to manage nematodes. The availability of Phytogen 427 WRF, DPL 1454 B2RF, and ST 4946 (recent root-knot resistant varieties) and site-specific application of Telone II are two of the most recent innovations in nematode management available to growers in Georgia.

Question 1. If I have a nematode problem in my field, should I plant one of the nematode-resistant varieties?

Answer 1. As a grower you MUST consider this option (see further notes below). Before you make this decision, insure that the nematode problem in the field is caused by southern root-knot nematodes and not others, e.g. reniform, sting or Columbia lance.

Question 2. If I plant one of the root-knot nematode resistant varieties, do I still need to use a nematicide? Am I better off planting a "highest yielding variety" and treating with a nematicide?

Answer 2. The short answer is that these resistant varieties will certainly perform better than susceptible varieties in terms of decreased root-damage and reduced build-up of nematodes in the soil. This does not necessarily translate into increased yield. Recent data demonstrates that even the resistant varieties may benefit from use of a nematicide like Telone II when nematode populations are severe.

Question 3. Will Counter 20G be labeled for use on cotton in Georgia in 2015?

Answer 3. Though a Section 18 Emergency Useage Label was granted by the EPA for use in 2014, it is not known (at time of this printing) whether or not the Section 18 will be extended for use on cotton in 2015. Additionally, efforts consider to compile efficacy data from trials conducted in 2014.

Question 4. What is "VELUM TOTAL"?

Answer 4. Velum Total is a new product from Bayer CropScience that has the combined power for management of nematodes and thrips. It is hoped that this product will be labeled and available to cotton growers in Georgia in time for the 2015 planting season. The University of Georgia and Bayer CropScience have cooperated on numerous field trials and results are promising. More information will be made available as the season approaches and once Velum Total is labeled.

Further notes on management of nematodes:

A. **Cotton with proven resistance to the southern root-knot nematode: Phytogen 427 WRF, DP 1454NR B2RF, ST 4946GLB2, PHY 367 WRF**, **ST 5458B2RF**, and **ST 4288B2F** are cotton varieties with a measurable level of resistance to **southern root-knot nematodes** (there is no benefit on reniform or Columbia lance nematodes). (Although the seed companies refer to this partial-resistance as "tolerance", it truly is "resistance".)

B. Results from UGA research trials document that benefits to planting the above varieties in a field where southern root-knot nematode is a problem include:
    a. Less damage to the root system than if a susceptible variety was planted.
    b. Signficant reduction in nematode populations in the soil at the end of the season than would be if a susceptible variety was planted.
    c. NOTE: the above benefits contribute too, but do not gurantee, that a more-resistant variety will out-yield a susceptible variety, even where nematodes occur.

C. With the loss of Temik 15G, the use of Telone II should become more common among cotton growers, especially if the supply of Telone can be stabilized. Also, there continues to be a move by our Cooperative, Extension, Dow Agrosciences, growers and consultants to develop "risk management zones" within a commercial field which could be treated with different rates and/or types of nematicides based upon threat from parasitic nematodes. In such a way, use of Telone II is reserved for areas that are most likely to need the extra "power" of this fumigant. Results from studies conducted since offer further assurances as to the benefits from use of Telone and the future for site-specific applications.

D. **Management after Temik 15G. (NOTE: Further recommendations will be provided if Velum Total or Counter 20G are labeled for use on cotton in 2015. Such information will be available through your local UGA Extension office.)** Below are UGA recommendations for management of nematodes on in absence of Temik 15G.
    a. In the absence of Temik 15G, it is hoped that growers who have resisted adoption of fumigation with Telone II at 3 gal/A will consider doing so now. Certainly there are costs associated with use of Telone II; however no product currently available in cotton production offers the same level of protection against all parasitic nematodes affecting the crop. Additionally, Dow AgroSciences had obtained a label for the at-plant application of Telone II when environmental conditions are favorable and the company is also working to develop variable-rate strategies and risk management zones where fumigation only occurs where nematode populations warrant the treatment. In difficult situations, fumigation with Telone II provides significantly better control of nematodes than does Temik 15G. Growers who fumigate with Telone II must remember that this product can provide excellent control of nematodes but does not control thrips.
    b. In addition to Telone II, cotton growers can use seed-treatment nematicides AVICTA Complete Cotton from Syngenta, AERIS Seed-Applied System from Bayer CropScience, and Accelron N from Monsanto for control nematodes. AVICTA Complete Cotton and Accelron N both contain abamectin (Avicta) and thiomethoxam (Cruiser); however the Syngenta product uses azoxystrobin (Abound or Quadris) for additional seedling disease control whole Monsanto uses pyraclostrobin (Headline) for additional seedling disease control.
    c. At lower nematode populations, both AVICTA and AERIS can be comparable in efficacy to Temik 15G at 5 lb/A for management of nematodes. As nematode populations increase, Temik 15G, 5 lb/A provided better early season management of southern root-knot nematodes and increased yields over the seed treatments. From these studies, both AVICTA and AERIS can be used effectively in the management of nematodes, but not with the same spectrum of activity that Temik 15G, 5 lb/A, had
    d. Note: Use of a post emergent application of Vydate CLV (17.0 fl oz/A) may help in the management of nematodes and thrips when used to compliment a seed treatment. The post emergent application of Vydate CLV (initially between the 2nd and 7th true leaf) is hoped to extend the protective window from a seed treatment

nematicide. Talk with representatives from DuPont to learn how VYDATE CLV (17.0 fl oz/A) may be used in conjunction with seed-treatment nematicides for additional management of nematodes and thrips.

e. For management of plant-parasitic nematodes, rotate fields with non-host crops.
f. Where southern root-knot nematodes are a problem, consider planting root-knot nematode varieties mentioned earlier; also consider using a seed-treatment nematicide in conjunction with these varieties to further improve control of nematodes.

Diseases and Nematodes in Cotton: A primer for growers

The importance of diseases and nematodes in cotton production is easy to overlook since the cotton plant is less severely affected by disease than are other crops and symptoms caused by nematodes can be easily misdiagnosed. Many growers may not recognize the price that they are currently paying to fight disease. For example, the cost of basic fungicide seed treatments is included with the price of their seed, and growers may plant at an increased seeding rate, in part to off set potential losses from a poor stand due to seedling disease.

A grower can effectively reduce the impact of diseases and nematodes on his crop by making sound management decisions. These include the use of crop rotation, choice of planting date, fertility and plant growth management, and choice of cotton variety. Although difficult for some growers, good crop rotation with crops that are non-host for major cotton pathogens remains one of the most effective means of reducing losses in cotton.

Seedling Diseases

Seedling diseases are widespread but typically not a major problem in Georgia cotton in most years. However, economic loss to seedling diseases can be significant at specific locations, especially when weather conditions are cool and wet at planting time and the grower is not able practice good crop rotation. Seedling diseases are caused by fungi that either survive on the seed or that live in the soil and infect seeds or developing seedlings. By far, the most common cause of seedling disease in Georgia is the fungus *Rhizoctonia solani*; however *Pythium* spp. and *Fusarium* spp. May also damage young plants. Generally as the young plant matures it becomes less susceptible to infection by these pathogens.

Seedling diseases are differentiated by the stage of development of the seed and young plant when symptoms occur.

1. **Seed rot** is the first disease in this sequence and is easily identified by the presence of decayed seed; however the problem is often detected only after the grower notices "skips" in the stand. Seed rot may be caused a number of different fungi that can exist either in the soil or on the seed itself.
2. The second disease in this sequence is **pre-emergence damping-off** where a fungal pathogen attacks the young seedling after germination but before it cracks the soil surface. Like seed rot, pre-emergence damping-off results in skips in the stand.
3. **Post-emergence damping-off** occurs once the seedling has emerged from the soil. It isidentified by the presence of a brown lesion at, or just below, the soil line that will eventually expand and girdle the young, succulent stem. Once the stem is completely girdled, the young plant will quickly wither and die. In the case of "hill-dropped" cotton, it is a common that if one seedling in a hill is diseased, all of the seedlings will be affected. Post-emergence damping-off is often referred to as "soreshin" in Georgia and is caused by the fungus *Rhizoctonia solani*. It is perhaps the most common seedling disease of cotton in the state and the one with which growers are most familiar. Although seedling disease caused by

Pythium spp. is less common, it still occurs and is characterized primarily by a water-soaked root rot, either before or after emergence. As will be discussed later, it is important to identify the pathogen(s) that is/are responsible for seedling disease in a field as *Rhizoctonia solani* and *Pythium* spp. may not be controlled by a single fungicide

Management of Seedling Diseases

Control of seedling diseases of cotton begins with the use of a fungicide seed treatment. All commercial seed sold in Georgia is pre-treated with at least two fungicides. **Growers should never plant cotton seed that has not been treated with a fungicide**. Some seed treatments, such as thiram and captan, are protectant fungicides that protect the seed from fungi borne on the seed or in the soil associated with the seed. Other treatments such as Vitavax (carboxin), baytan, metalaxyl (Allegiance), and mefenoxam (Ridomil Gold) have systemic activity and when absorbed in the seedling, offer some protection immediately following germination. Growers can greatly minimize the effect of seedling diseases by avoiding conditions in which seeds/seedlings are at risk to damage from fungal pathogens. Cool, wet weather at planting and low soil temperatures produce an environment that not only slows germination and emergence, but may also favor fungal growth and infection. *Pythium* can be especially troublesome in saturated soils; *Rhizoctonia solani* is less dependent on soil moisture or temperature. **NOTE: Growers should avoid planting cotton seed when rain and colder soil temperatures are likely, even if seedling disease is not an issue.** Rapid germination and vigorous growth by the seedling are factors which help to insure the survival of the young plants. Slower growth early in the season gives the fungal pathogens more time to infect the vulnerable seed and seedling. The sooner the seedling develops hard, "woody" tissue, the less likely it is to be penetrated and rotted by fungi.

Good management practices to reduce the chance of disease include the following:

1. Plant in warm soils where the temperature at a 4-inch depth is above 65° F and where the 5-day forecast doesn't call for cooler or cooler/wetter weather. **NOTE:** Cotton growers should **NOT** plant cotton if at all possible when conditions are cool and wet or if the forecast calls for such conditions soon after planting, even if they plan to use additional fungicide treatments!
2. Plant seed on a raised bed since soil temperatures in the bed are generally slightly warmer than surrounding soil and drainage is likely to be better. Cotton planted in conservation tillage is not grown on raised beds, thus potentially increasing the threat from seedling disease.
3. Avoid planting seed too deeply. Seed that is planted too deeply results in longer periods before the young seedling cracks the soil surface, increasing the likelihood of seedling disease.
4. Correct soil pH with lime (pathogenic fungi are more tolerant to acidic soils than are cotton seedlings; pH should be in the range of 6.0 to 6.5).
5. Fertilize according to a soil test so as to promote rapid seedling growth; however care should be taken to avoid "burning" the seedling with excessive rates of at-plant fertilizers.
6. Avoid chemical injury through the use of excessive amounts or improper application of insecticides, fungicides, or pre-plant herbicides.
7. Plant only high quality seed as indicated by the percent germination in the standard seed and cool germination tests. Preferably, cool germination test results should be above 70%, though 60-69% is still adequate.

Additional seed treatment fungicides such as Dynasty CST, Trilex advanced, and Accelron, beyond the "base" treatment can significantly reduce the amount of seedling disease, increase stands, and potentially improve final yields where conditions are favorable for disease development. However, significant outbreaks of seedling diseases are a sporadic problem. Because we cannot reliably predict which years will have greater amounts of seedling disease, growers can become justifiably frustrated when trying to determine the economic benefit of the additional fungicide.

As significant yield losses to seedling disease are sporadic in Georgia, the Cooperative Extension does not recommend an additional fungicide treatment for each and every cotton field. Numerous field trials have been conducted by researchers at The University of Georgia assessing the benefits of seed treatments, hopper box treatments, and in-furrow fungicides. It has been very difficult to document significant yield benefits from these products despite increases in stand that may occur.

When a grower is assessing the need for additional protection from seedling diseases, he should note the following.

1. Any field with a history of cotton seedling diseases should be considered a prime candidate for the use of these additional fungicides and seed treatments.
2. This is especially true when a poor history is combined with any combination of the following: a. cool, wet weather at planting, b. poor seed quality, c. conservation tillage (which tends to keep the soil cooler and perhaps moister than conventional tillage), d. a low seeding rate, or e. the use of an in-furrow insecticide or nematicide. The risk for losses to seedling disease increases in fields where multiple factors, as described above, apply.

Final note on seedling diseases: It is important to understand that fungicides which are effective on *Rhizoctonia solani* may not be effective on *Pythium* spp., and vice versa. For example, PCNB is active against *Rhizoctonia* but not *Pythium*. Metalaxyl, mefenoxam, and etridiazole are active on *Pythium* spp. but not *Rhizoctonia*. The tables below includes detailed information on chemical treatments for seedling diseases.

<u>Fusarium Wilt</u>

Fusarium wilt is a fungal disease that typically becomes evident in mid-season, though it can occur at any point in the growing season. **In 2013 and 2014, severe outbreaks of Fusarium wilt were observed in Pierce, Tift, Jeff Davis, Evans, Cook, Grady, Thomas and Berrien Counties**. Fusarium wilt is not currently a wide-spread problem in Georgia; however there are fields throughout the state where losses can be significant. For some reason, Fusarium wilt seems to be more problematic in southeastern Georgia than in other acreas of the state. Fusarium wilt is becoming of increasing concern.

In cotton, Fusarium wilt is usually found in association with infections by the southern root-knot nematode, which has a synergistic effect on this disease. Although root-knot nematodes are most often associated with Fusarium wilt, other parasitic nematodes such as Columbia lance, reniform, and sting nematodes also injure cotton roots and increase the severity of the disease. As populations of parasitic nematodes increase throughout the state from inadequate crop rotation, it is possible that Fusarium wilt will become a more serious problem. **Recommended control measures for this disease are to plant nematode-resistant cotton varieties and to control root-knot and other nematode infestations.**

The most visible symptom of Fusarium wilt is the presence of wilted and dying cotton plants in a field. Some plants may be stunted and the leaves may yellow between the veins (also know as interveinal chlorosis). Root-knot nematodes alone can cause wilting, but the synergistic effect with the Fusarium fungus is usually required to kill plants, unless the soil is extremely dry for prolonged periods. Fusarium-infected plants wilt even if soil moisture is adequate because of damage to the vascular system that carries water throughout the plant.

A preliminary diagnosis of Fusarium wilt can be made fairly easily in the field by slicing through the plant stem at a shallow angle to expose the vascular tissue. Fusarium wilt will cause a noticeable browning of the vascular tissue. This discoloration is the result of damage to the vascular tissue which prevents adequate flow of water and nutrients. If you **carefully dig** up the root system of wilting plants, you will also usually see significant galling caused by root-knot nematodes. To verify the diagnosis, submit a sample through your county agent to the UGA Plant Disease Clinic. You should also submit a soil sample for nematode assay to the UGA Extension Nematology Laboratory.

Plants affected by Fusarium wilt tend to be clustered in the field rather than randomly spaced. In fact, areas of the field where Fusarium wilt occurs will probably be consistent from year to year. This is because the fungal pathogen and the associated parasitic nematodes tend to be unevenly distributed in the field.

Additional information on Fusarium wilt in cotton can be found in University of Georgia Extension Bulletin 1143, "Cotton Diseases and Their Control." and "Cotton Nematodes and Fusarium Wilt", Leaflet L 82, 1996.

Nematodes

An estimated 60 to 70 percent of Georgia's cotton fields are infested with at least one species of potentially damaging nematodes. In a recent statewide survey of cotton fields (nearly 1800 samples were submitted by agents from randomly selected fields in 2002) approximately 69 percent of the fields were infested with root-knot nematodes, 2.8 percent with Columbia lance nematodes, 4.6 percent with reniform nematodes, and 0.6 percent with sting nematodes. While the southern root-knot nematode is responsible for the greatest amount of damage to cotton in the state, the Columbia lance and reniform nematodes also cause tremendous damage in more restricted areas, e.g. in the heavier soils along our the fall-line between the Piedmont and the Coastal Plain. Every cotton grower in the state of Georgia either has a problem with nematodes now or is at risk for such a problem should they lose the ability to practice effective crop rotation.

If damage to cotton from parasitic nematodes is such an important problem in Georgia, one may question why more attention is not devoted to this pest. There are three basic reasons. First, many growers do not recognize the symptoms of nematode damage as they can appear similar to drought stress, poor soil fertility, and injury from herbicides. Second, nematodes are microscopic worms that are not easily viewed by the growers. Third, many growers feel that they cannot afford to treat with nematicides because of the perceived cost associated with such treatments. Nothing could be further from the truth.

Symptoms of Nematode Damage

Symptoms of damage from nematodes in a field are variable and are dependent on the species of

parasitic nematode infecting the plants. Damage from reniform nematodes may be evident in the seedling stage where severely infected plants wilt and die. Stunting throughout the season is the most readily recognized symptom of severe infection by root-knot, reniform, and Columbia lance nematodes. In some cases, stunting may approach 50%, and infected plants are likely to show drought stress earlier than healthy plants. However, plants infected with low levels of reniform nematode may actually grow taller and larger than healthy plants as nutrition is going to vegetative growth rather than filling bolls. Although foliar symptoms are not the direct result of infection by parasitic nematodes, infected plants often show nutrient deficiencies, e.g. nitrogen and potassium, in the leaves. The leaves may be slightly yellowed, and in more advanced cases, interveinal chlorosis and leaf scorch may occur.

It is often useful to examine the root systems of plants suspected to be infected with parasitic nematodes to further diagnose the problem. It is important to carefully dig and remove the roots from the soil to preserve the finer secondary roots; roots infected with root knot nematodes often develop swellings and galls that are most evident on the finer secondary roots. The galls can be fairly small, but are visible if the roots are examined carefully. The tap roots from plants infected with the Columbia lance nematode are often severely stunted because of feeding at the growing tip by the nematodes. Secondary roots are also often severely stunted. Root systems from plants infected with reniform nematodes may appear normal because this parasite does not produce galls or severely stunted taproots. However, small clumps of dirt particles (containing egg masses) may be visible on the roots with the aid of a magnifying glass.

Crop Rotation

Crop rotation is a critical tool for nematode management in Georgia's cotton and should be used where economically feasible. Alternating cotton crops with non-host crops will help to reduce the size of the nematode populations in a field. Although this reduction may not be sufficient to eliminate the need of a nematicide in all fields, it will allow the grower to receive better effectiveness and larger yields from lower rates of nematicides. Common rotation crops to help manage nematodes damaging to cotton include the following: peanut and certain forage crops for southern root-knot nematode; peanut, and certain forage and vegetable crops for Columbia lance nematode; peanut, corn, and certain forage and vegetable crops for reniform nematode. Corn is a host crop for several important species of root-knot nematode, but recent research documents that the root-knot species found in soil samples from corn fields will almost always be the southern root-knot nematode regardless of previous crop. Therefore, when planting cotton following corn, it should be assumed that any root-knot nematodes found in a soil sample from corn will also be damaging to the subsequent cotton crop. Additional information can be found in UGA Extension Bulletin 904 "Plant Susceptibility to Major Nematodes in Georgia."

Growers who practice conservation tillage often have questions regarding cover crops and nematode management. Common cover crops such as wheat, oats and rye are somewhat susceptible to the southern root-knot nematode. However, because nematodes are inactive during the winter months when soil temperatures are cold and because wheat, oats and rye are fairly poor hosts for the southern root-knot nematode, these cover crops can be planted without increasing the nematode problem in the next cotton crop.

Leguminous cover crops, such as clovers and vetches, are also popular in conservation tillage, especially with the current cost of nitrogen. However, growers who have problems with southern root-knot nematodes in a field should exercise caution in planting vetches or clovers as cover crops because they are very good hosts. Though cold soil temperatures in the winter will reduce

the build-up of nematodes on clover and vetch, the nematodes will become active once the soil begins to warm up in the spring. Growers who wish to plant vetches or clovers in a field where southern root-knot nematodes are present should seek to find a resistant variety, if one exists.

Nematodes and Stress

Nematodes are considered "stress" pathogens because of the sub-lethal damage that they typically cause to the root system. In addition to crop rotation, one very effective way to reduce the effects of nematodes in a field is to reduce the stress on the cotton crop. Fertility, pH, hardpan and water problems exacerbate plant injury due to nematodes and should be corrected. Irrigation can reduce, but not eliminate, yield losses caused by nematodes. Growers should wash soil from equipment that is being moved from infested to non-infested fields in an attempt to minimize the spread of the parasitic nematodes.

Nematicides

Nematicides are an important component in the management of nematodes on cotton. Despite their effectiveness, nematicides cannot completely compensate for poor crop rotation. Recommendations to use a nematicide are usually based on the results of a nematode assay from a soil sample collected near harvest of the previous year's cotton crop. Nematicides, e.g. AVICTA Complete Cotton, AERIS Seed-Applied System, and Telone II, can provide cost-effective control of nematodes when yield losses are expected to exceed approximately 10% or when results from a soil sample exceed a predetermined economic threshold. The choice of one of these products over another is influenced by factors such as the potential severity of losses to nematodes in a field versus the level of control offered by the product, application capabilities of the grower, and cost. Although growers may be concerned about the initial cost of using a nematicide in a field with damaging populations of parasitic nematodes, the resulting increase in yield will often provide a very good return on the investment. Nematode threshold levels and nematicide options also are given in Appendices III and IV. Additional information can be found in UGA Extension Bulletin 1149 "Cotton Nematode Management," UGA Extension Circular 834 "Guide for Interpreting Nematode Assay Results," and UGA Extension Bulletin 1160 "Controlling Nematodes with Soil Fumigants."

Seed Treatments and Nematodes

AERIS Seed-Applied System is a product from Bayer Cropscience and includes a mixture of the active ingredient thiodicarb for nematode management and Gaucho (imidacloprid) for thrips control. An additional fungicide for control of seedling diseases is not automatically included with AERIS Seed-Applied System (as it is in AVICTA Complete Cotton). However, an additional fungicide seed treatment (Trilex) may be added to AERIS if the grower feels such is needed. By keeping the addition of the fungicide optional for the grower, Bayer Cropscience is able to keep the cost of the key components- a nematicide and a thrips management insecticide, at a lower price.

AVICTA Complete Cotton is composed of Avicta (abamectin) for management of nematodes, Cruiser (thiomethoxam), for early season thrips management, and Dynasty CST for additional protection from seedling disease. Growers who wish to use AVICTA Complete Pack can either pre-order the product with their seed or have it treated at special facilities after acquiring the seed. AVICTA Complete Pack is to be marketed as comparable in efficacy to 5.0 lb/A of Temik 15G. That is, Syngenta is confident that AVICTA Complete Pack will provide control of nematodes similar to that of Temik 15G at 5.0 lb/A.

After reviewing the data that has been collected for the nematicidal activity of AVICTA Complete Cotton and AERIS Seed-Applied System by the University of Georgia, it is evident that these seed treatments are a popular and valuable tool for growers. However, Temik 15G (5 lb/A) had efficacy at higher/more damaging populations of nematodes than do the seed treatment nematicides. This is based upon ratings of early season galling on the cotton roots and on final yields. Based upon the loss of Temik and the ease with which seed-treatment nematicides are used in the field, fewer growers no longer ask, "Is AVICTA Complete Cotton (or AERIS Seed-Applied System) AS GOOD as Temik 15G (5 lb/A)?" and should now as "Is AVICTA Complete Cotton or AERIS or Accelron N GOOD ENOUGH for my field and, if not, what other options do I have?".

Use of Vydate C-LV (oxamyl)

Vydate C-LV is an insecticide/nematicide that is applied as a foliar spray to cotton typically at 17.0 fl oz/A between the 5th and 8th true-leaf stage of cotton development. This application is a supplemental treatment for earlier applications of Telone II or use of AVICTA Complete Pak or AERIS Seed-Applied System. Use of Vydate C-LV is quite popular with cotton growers in the mid-south (e.g. Mississippi), but much less so in Georgia. For whatever reason, it is has been difficult to show consistent yield increases when assessing Vydate C-LV in our trials; **however use of Vydate is certainly an option for growers who seed additional protection from nematodes after cotton seedlings emerge.**

<u>Development of Risk Management Zones as a tool for nematode management in cotton.</u>

Plant parasitic nematodes, especially root-knot nematodes, are often unevenly distributed across a field. Because of this "patchy" distribution, the damage attributable to nematodes in a cotton field is often highly variable from one point to another. Much of this variation is the result of differences in the characteristics of the soil.

Accurate identification of different risk zones in a field should be attractive to cotton producers. If growers can determine risk zones across a field based initially on soil type (measured indirectly through the use of soil electroconductivity values) and subsequent sampling for nematodes, then they can use this information to refine use of nematicides in a field. For example, in areas of the field where risk to nematodes is more severe, then growers may choose to use more effective, but more expensive, treatments such as fumigation with Telone II. Where risk to nematodes is known to be reduced, growers may choose to use nematicide seed treatments.

Growers who are interested in developing risk management zones for nematodes in their fields should consider the points listed below:

1. Southern root-knot nematodes are the key plant parasitic nematode affecting cotton in much of Georgia.
2. Southern root-knot nematodes are often unevenly distributed in a field; largely as a factor of soil type.
3. Populations of southern root-knot nematodes tend to be proportional to the percentage of sand in the soil in a field. Larger percentages of sand often support higher levels of nematodes; higher percentages of silt and clay (heavier soils) tend to have smaller populations of southern root-knot nematodes.
4. Southern root-knot nematodes tend to prefer the intersticial spaces of sands (spaces between sand particles) for ease of movement in the soil.

5. Risk management zones for management of southern root-knot nematodes are currently being studied and developed in a number of states, to include Georgia, South Carolina, and Louisiana.
6. In Georgia, Risk Management Zones are developed largely on the use of VERIS rigs that map soil conductivity in a field. Higher soil electrical conductivity (EC) indicates more silt and clay and less sand. Lower soil EC values indicates more sand.
7. Maps can then be drawn to split the field into zones with higher EC values and lower EC values.
8. The OPTIMIUM use of these maps is to focus nematode sampling efforts to confirm populations in higher risk zones and lower risk zones. It is NOT sufficient to simply determine choice of nematicide based upon soil EC maps.
9. Remember: Soil EC values indicate the possibility for different populations of nematodes but not necessarily the reality. For example, there are certainly very sandy fields in the state that have few if any southern root-knot nematodes, often because of great crop rotation. In other fields a grower may be able to define Risk Management Zones based upon soil EC; however the differences in EC may not be of biological significance and the entire field would benefit from a nematicide like Telone II (hence the need to take nematode samples.)
10. Finally, even though there may be Risk Management Zones in a field appropriate to treat with different rate/nematicides based upon nematode samples, there may also be OTHER agronomic factors (e.g. fertility, moisture retention, etc) that may keep zones from yielding as hoped.
11. FINALLY: I truly believe that when used appropriately, risk management zones ARE a very important tool for the best cost-effective management of nematodes in Georgia.

Boll Rot

Boll rots are caused by a complex of fungal and bacterial pathogens. Boll rot is unavoidable if cotton is subjected to prolonged periods of wetness and humidity late in the growing season. In Georgia, this can happen if a tropical storm or hurricane causes excessive rainfall, especially over a several-day period. In such situations, there is little a farmer can do to minimize losses to boll rots.

Actions that reduce humidity in the cotton canopy can help reduce the likelihood of a significant boll rot problem in the absence of inclement weather. Such practices include proper nitrogen fertilization to avoid rank vegetative growth, lower plant populations (plants/acre), timely defoliation and harvest, and the use of mepiquat chloride, a plant growth regulator which limits vegetative growth. These practices increase airflow through the canopy and reduce humidity around the lower bolls which makes the microclimate less conducive for boll rots. Adjusting planting dates so that bolls approach maturity later in the summer, when conditions are typically drier, can help. Neither fungicides nor bottom defoliation have proven effective for boll rot control. Plants with fewer bolls may have increased vegetative growth, which can increase humidity in the plant canopy thereby increasing boll rot problems. For additional information, refer to UGA Extension Leaflet 143, "Cotton Boll Rot."

Good insect control can reduce boll rot. Injury from insect feeding can increase boll rot by creating wounds where rot-inducing organisms can enter bolls and by causing plants to set fewer bolls. Also, proper insect control can promote better plant utilization of nitrogen, thus reducing excessive vegetative growth.

Assessing Risk to Target Spot in Georgia

A draft of a risk-management tool to be assessed and refined in Georgia/Revised 12 February 2013

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Factor with the **HIGHEST impact** on increased risk to target spot:

a. **Location of the field.** The risk to significant outbreaks of target spot seem greatest in SW Georgia, SE Alabama and NW Florida. 25 pts

b. **Location of the field.** Field is located in central and SE Georgia. 15 pts

c. **Location of the field.** Field is located in eastern Georgia. 5 pts

Factors with **MODERATE impact** on increased risk to target spot:

1. **Field History.** Target spot is likely to occur again if fields where it has been severe in the past if environmental conditions are favorable.
   a. **Target spot has been severe** in the field in the past. 15 pts
   b. **Target spot has been observed** but has not been severe. 5 pts
   c. **Target spot has not been observed.** 0 pts

2. **Rank cotton growth.** The development and spread of target spot seems closely tied to extended periods of leaf wetness. Foliage within the dense canopy of cotton stays wet longer and is thus more prone to target spot.
   a. **Rank cotton with dense canopy.** 15 pts
   b. **Cotton with complete closure but growth well managed.** 5 pts
   c. **Cotton with open canopy and good airflow.** 0 pts

3. **Irrigation.** As above, irrigation can both improve the growth of the cotton plants and extend periods of leaf wetness, thereby increasing the risk to target spot.
   a. **Cotton irrigated during day, extending dew period from previous night.** 10 pts
   b. **Cotton is irrigated at night or early morning to minimize leaf wetness period.** 5 pts
   c. **Cotton is not irrigated.** 0 pts

4. **Extended periods of rainfall and cloudy weather.** Such conditions create conditions where disease is favored.
   a. **Frequent periods of extended rainfall of cloudy conditions.** 10 pts
   b. **Rainfall events "normal" for the season.** 5 pts
   c. **Growing season is extremely dry.** 0 pts

Factors with **LOW** impact on increased risk to target spot**:**

1. **Tillage.** Spores of the target spot pathogen, *Corynespora cassiicola*, will survive in the crop debris from previous cotton crops. Spore survival is expected to be longer in reduced-tillage conditions and spores may also be splashed to cotton leaves easier from such debris.
   a. **Conservation tillage/reduced tillage.** 5 pts
   b. **Conventional tillage with deep turning.** 0 pts

2. **Crop rotation.** Although this remains to be proven, it is likely that target spot on cotton will be more severe in fields where cotton is planted behind cotton or in in short rotations. This is because the spores of the pathogen will survive among the debris from recent cotton crops.
    a. **Cotton planted behind cotton.** 5 pts
    b. **At least one year of another crop between cotton crops.** 0 pts

Factor that **MAY have impact** on risk to target spot**. Variety Selection.**

Variety selection. It is likely that some varieties of cotton may be more susceptible to target spot than are others. However it is not clear whether such an increase in susceptibility is because the pathogen can more easily infect the leaves of the cotton plant or because of the growth habit of the variety tends to be more-rank and thus prone to longer periods of leaf wetness. Also, the exact relationship between defoliation and yield loss is not completely understood. For example a variety with more defoliation than another variety may not necessarily yield less.

YOUR RISK

High Risk: Growers with the greatest risk to target spot and most likely to see some benefit to use of a fungicide program are those with a total risk of **40 points or more**.

Moderate Risk: Growers at **moderate risk to target spot** and could benefit from the use of a fungicide are at risk levels from **25 to 35 points**.

Low Risk: Growers with the **least risk to target** spot are those with risk levels below **25 points**.

Timing of fungicide applications: Growers are advised to begin scouting their fields at the approach of first bloom to determine if target spot is present in the crop. From research conducted in Georgia, the optimum timing for an initial fungicide application is sometime between the first and third week of bloom; an additional fungicide application may be needed approximately 3 weeks after the first application.

Target Spot: Target spot is caused by the fungal pathogen ***Corynespora cassiicola*** and is most severe during periods of extended leaf wetness. Target spot is easily identified by the presence of marble-size spots on a leaf that frequently demonstrate a pattern of concentric rings. Infection and premature defoliation typically begin in the lower leaves of the plant and progress up the plant. Significant defoliation can occur very quickly after initial detection of the disease. Defoliated leaves typically retain their green or green-yellow color. Lesions are also found on the boll bracts and possibly on the bolls themselves. Fungicides have been shown to aide in the management of this disease.

Stemphylium Leaf Spot: Stemphylium leaf spot is caused by the fungal pathogen *Stemphylium solani* ; however the underlying cause of this disease is actually the result of a deficiency in potassium in the plant. This disease is analogous to Alternaria leaf spot (*Alternaria macrospora*) in Texas. Symptoms of this disease include a sudden reddening of the foliage of the cotton plant and the raqpid appearance of numerous spots with ashy-gray centers and a dark purple margin. The centers of the spots frequently detach from the leaf giving the leaf a shot-hole appearance. The use of fungicides to manage Stemphylium and Alternaria leaf spot diseases has been largely unsuccessful.

Cercospora Leaf Spot: Like Stemphylium leaf spot and Alternaria leaf spot, Cercospora leaf spot (*Cercospora gossypina*) is often linked to a nutrient deficiency in the cotton crop and may form a disease complex with Alternaria mascrospora and Stemphylium solani. Spots begin as small, reddish lesions that larger circular lesions with light brown centers; zonation similar to that of target spot may be observed. As

this disease is associated with nutrient deficiencies, fungicides are not considered to be an effective control measure.

Areolate Mildew: Areaolate mildew, cause by the fungal pathogen *Ramularia areola*, is of limited importance in Georgia and is generally confined to the southeastern region of the state, especially during periods of abundant rainfall. The disease is easily identified by the presence of abundant white-to-gray sporulation on the underside of the affected leaves. The affected leaves often drop prematurely resulting in significant defoliation. This disease can be effectively managed with the use of fungicides, especially strobilurin fungicides; however it is not clear at this time how much yield loss is associated with the disease.

Ascochyta (wet weather) blight: Ascochyta blight, caused by *Ascochyta gossypii*, is a disease of sporadic importance in Georgia, especially during periods of cool weather with abundant rainfall early in the season. Hence, young plants are most often affected. The spots in the field can be tentatively diagnosed by the presence of tan lesions bordered by a dark ring; embedded in the lesion are dark fungal structures that appear like pepper grains. Though use of fungicides for effective management has been reported, such is generally considered unnecessary in Georgia. This disease tends to become of little significance as conditions become drier.

Angular (bacteria) Leaf Spot: Angular leaf spot is caused by the bacterial pathogen *Xanthomonas campestris* and is of limited importance to cotton producers in Georgia. The disease is most common in periods of extend rainfall. Lesions/spots on the leaves are quite distinctive as they are defined by the veins on the leaf, thus creating the "angular" appearance. This pathogen can also cause water-soaked lesions on the bolls themselves leading to rot. As this is a bacterial pathogen, use of fungicides is not an effective management tool. This pathogen can be seed transmitted.

PLANT GROWTH REGULATOR USE

The best "growth regulator" for cotton is good, early fruit set and retention, as this will generally deter excess vegetative growth. Therefore, nitrogen levels, soil moisture, insect control, plant population, and crop management influence the cotton plants' ability to balance vegetative and reproductive growth. There are two ways to influence the plants' vegetative/reproductive balance. An indirect influence would be timely applications of boron, which aids flowering and fruit set. As a management tool, growth regulators containing mepiquat are specifically used to reduce vegetative growth. Mepiquat is available in several formulations sold under the trade names of Pix, Pix Plus, Mepex, Mepex Ginout, Topit, Mepichlor, Pentia, and Stance among others. Mepiquat has a number of effects on cotton growth and development. The most consistent effect of mepiquat is the reduction of plant vegetative growth and shorter plants by shortening internode length. It also reduces leaf area in portions of the plant canopy where stem and leaf expansion are taking place. It controls growth in such a way that does not create carbohydrate stress in the plant.

Mepiquat applications are also often associated with a slight increase in early fruit retention and thus, contributes to a trend toward early maturity. Yield responses have been erratic and inconsistent. Slight increases, slight decreases, and no effect are prevalent in the volumes of research dealing with mepiquat. Yield advantages observed with mepiquat-containing products are most often linked to situations in which the product contributes toward increased harvest efficiency, improved insecticide/defoliant penetration through the canopy, hastened maturity (in

later planted cotton), and retention of earlier-set larger bolls. Most conditions that would likely result in a positive response to mepiquat are not easily predictable, except for some problematic and/or irrigated fields that historically result in adversely tall plants. With the wide range of growth potential among our current modern varieties, it is important to understand the growth potential of any particular variety, and how the environment influences growth of a particular variety, before applying mepiquat. Slower growing earlier maturing varieties may seldom need aggressive PGR management (high rates, prebloom applications, etc) depending upon the prevailing environment. However, the environment (i.e. rainfall or irrigation) dictates the likelihood of excessive growth moreso than most of other factors. Field history often provides insight on the likelihood of excessive growth.

Mepiquat formulations which include the hormone kinetin (Mepex Ginout), or formulated as a pentaborate salt (Pentia) as opposed to a chloride salt (all others) have resulted in similar responses to other mepiquat-containing PGRs in UGA trials. Several recent small and large plot trials were conducted to evaluate Stance (a premix of mepiquat chloride and cyclanilide). This product is used at lower rates compared to other mepiquat-containing products. Recent experience with this product suggests that Stance, when used at appropriate application rates, has similar effects on plant growth and development, when compared to other mepiquat-containing products. Trials conducted in 2010 suggested that Stance applied at appropriate and recommended rates (usually 2.5 to 3 oz/a depending upon growth stage) may have milder effects on plant growth than the commonly used rates of other mepiquat-containing PGRs. Therefore, Stance may reduce risks of severe stunting due to hot or dry weather following application, especially for early maturing varieties or varieties that generally portray less aggressive growth.

Currently UGA data indicates that all mepiquat-containing products should be used at the same rates and timings, with the exception of Stance. *The use rate of Stance recommended by Bayer CropScience is 3 oz/A in all situations. This rate may be lowered to 2.5 oz/A if the first application is made prior to, or at the initiation of squaring*.

Even though mepiquat has been available for over 25 years, questions persist about how to use the product. Indications from the literature show that a given rate of mepiquat in a small plant leads to more height/growth reduction than that same rate in a large plant. This is related to concentration -- the concentration of a given rate of mepiquat will be greater in a small plant and more dilute in a large plant. If the product is applied when vegetative growth is nearly complete, little effect on height occurs. After a leaf has fully developed and internodes have elongated, no amount of mepiquat can shrink them. Vigorous plants show less response (reduction in internode length, duration of growth control, etc.) than slower growing plants. In growth chamber studies in Mississippi, mepiquat had less effect on cotton grown at high temperatures ($>95^0$ F) or on plants under drought stress. Therefore, the activity of mepiquat is greater within plants that are actively growing, with good moisture under warm, moderate temperatures.

Factors that must be considered when determining when and how much mepiquat to use include: (1) stage of plant growth, (2) rate of plant growth, (3) pest control and (4) anticipated plant growth (irrigation, drought, fertility). Because of the many variables, hard and fast rules regarding the rate and timing of mepiquat are not appropriate. Fields vary in growth. Weather varies by year/location, and thus, recommendations must be flexible.

In most irrigated fields, we can comfortably begin low rate applications (4 oz) at least by the second week of squaring and continue on a 14-day interval for three or four applications. Another

common approach in irrigated conditions is to apply 8 to 12 oz at first bloom or just prior to bloom, with a subsequent treatment if needed at 8 to 12 oz two or three weeks later. The key to plant management for aggressive varieties may be making applications earlier, when the plant is 12 to 16 inches tall, especially in fields that frequently receive and retain moisture. In dryland situations, applications at, or just prior to, first bloom is usually a time to consider mepiquat at rates near 8 oz, if growth is vigorous. If aggressive growth continues, a follow up treatment may also be needed. These suggestions provide a framework upon which to base timing and rates.

A common error is to delay applications past the point where the product can provide its maximum benefit. If the intent is a single (or at most two) application program, growers should be targeting cotton in the 16 to 24 inch range. Applications that are not made until cotton reaches 30 inches often do not adequately control growth. However, some modern varieties appear to be less aggressive compared to DP 555 BR, in terms of growth rate and potential. Some of these varieties may not require aggressive use of mepiquat, while some may require multiple applications and higher rates depending upon the prevailing environment and moisture status. Therefore, it is very important for growers to closely monitor plant growth in all fields, and apply mepiquat accordingly, as every situation is different.

Late-season applications of mepiquat have received attention for several years. The theory behind these applications is that they will reduced vegetative growth at the time of cut-out thus channeling more energy into the development of late-season bolls. Current UGA research has not shown any yield advantage, nor any other advantage, resulting from mepiquat applied at this growth stage.

Questions related to ultra-early season applications of mepiquat have also surfaced. These questions have primarily centered around the management of aggressive varieties such as DP 555 BR. The thought is that applying 2 to 6 oz at the 4-leaf stage when the last over-the-top glyphosate application is made will provide additional vegetative growth control. Research to date has not shown any advantage with these early applications. Now that less aggressive and earlier maturing varieties are being planted, these very early applications may increase the risks associated with stunting.

Optimal growth control should result in plant height that is harvest efficient while avoiding excessively tall plants that may result in lodging, severe delays in maturity, loss of critical fruit, or obstruction of spray applications. However plants should be sufficiently tall to support adequate fruiting sites for optimal yields while achieving full canopy closure. Any plant growth regulation strategy should attempt to slow terminal growth enough to allow the increasing developing boll load to restrain vigorous growth, with terminal growth ceasing at an optimal plant height. Plant growth regulation strategies that are too weak (late applications, low rates) may result in suboptimally tall plants if growth is vigorous, while aggressive strategies (early/multiple applications, high rates) may result in insufficient plant height if stress is encountered. Therefore, these decisions need to be made on a case-by-case basis.

IRRIGATION

Although cotton is considered to be a relatively drought-tolerant crop, it is an excellent candidate for irrigation. Irrigation is particularly important in areas that frequently have drought in July through August and on sandy soils. Irrigation may increase yields from a range of 0 to more than 800 lb/A, with increases of 200 to 400 lb/A being common. Irrigation is often supplemental to rainfall, as total reliance on irrigation in the absence of periodic rainfall would be difficult for some producers to achieve with system sizing and water supply. The most critical period of water requirement is during the bloom and boll maturation periods. At peak bloom, the plant requires about 0.3 inches of water per day. However, recent UGA research indicated that timely irrigation with moderate rates during squaring (period when potential fruting sites are developing) may also have a strong influence on yields.

Many uncertainties exist as to HOW to irrigate. With the exception of 2009, 2012, and especially 2013, many years have been characterized by severe, persisting drought, and many irrigated fields have fallen well below expectations in terms of yield and fiber quality. Even in wetter years like 2012 and 2014, short-lived episodic dry spells have been shown to negatively affect yields in several situations.

A recent publication developed by Cotton Incorporated, "Cotton Irrigation Management for Humid Regions", is an excellent resource for growers that provides a broad, general overview of cotton irrigation for our region. This publication is available online at: http://www.cottoninc.com/fiber/AgriculturalDisciplines/Engineering/Irrigation-Management/.
In the past, irrigation of cotton prior to blooming was initiated when plants began to wilt or exhibited stress by mid-day. Recent research has indicated that once cotton begins to wilt, it has already been under physiological stress for some time and yield potential has been lost. Prior to bloom cotton will utilize 0.75 to 1 inch of water per week, which is most important during squaring (7-leaf stage to first bloom). Thus, under hot and dry early season conditions to optimize yield potential the crop should be irrigated at this amount prior to the signs of stress. It should also be recognized however, that abundant moisture magnifies vegetative growth problems when excessive nitrogen is available and/or insect control is insufficient. After first bloom, irrigate as needed to supply the quantities of water listed in Table 1. Rain gauges should be used to measure the water received from rain and the amount supplied by irrigation. An example of how to use these values is included below.

Table 1. Cotton Irrigation Schedule Suggested for High Yields

Crop Stage	Inches/Week	Inches/Day
Week beginning at 1st bloom	1	0.15
2nd week after 1st bloom	1.5	0.22
3rd week after 1st bloom	2	0.30
4th week after 1st bloom	2	0.30
5th week after 1st bloom	1.5	0.22
6th week after 1st bloom	1.5	0.22
7th week and beyond	1	0.15

Examine the crop during the 7th week and 8th week of bloom to determine if irrigation should be terminated. Additional irrigation may be needed on deep sands, during hot and dry weather, and

in windy conditions. It is generally recommended that irrigation be terminated when a noticeable number of bolls have opened, especially when the majority of harvestable bolls are located on lower plant nodes. However, if the majority of the targeted harvestable bolls remain relatively immature when only a few lower bolls begin to open, irrigation may still be required for a short time. Irrigation termination can be a difficult decision. A final irrigation event is often applied when the crop begins to open. Commonly, NO additional irrigation is applied once the crop reaches 10% open boll to minimize problems with boll rot, hard lock, light spot, and other fiber quality issues. Common sense factors for irrigation scheduling and reccomended application amounts include prevailing weather patterns and predictions, available soil moisture, and time of year.

Growers with intensely managed production programs that are already harvesting 2-bale yields and are striving for 3-bale-plus yields on part of their crop may want to either increase the amount of water supplied by irrigation if water availability appears to be a limiting factor. Additionally, as stated above over-irrigating can cause yield losses and excessive vegetative growth. Growers attempting to achive high yields should consider implementing a very roubust irrigation management plan, which could include the use of advanced irrigation scheduling tools that include but are not limited to consultants, soil moisture sensors, and online or smartphone app schedulers.

Irrigation Example

Step 1. The soil type of the field is a Tifton loamy sand. In Table 2, the average available water holding capacity is 0.9 inches/ft. Assuming a rooting depth of 2 feet, the total available water is 1.8 inches (2 ft x 0.9 inches/ft).

Step 2. If the cotton crop is determined to be during the 3rd week of bloom. From Table 1, the daily water use by the crop is 0.3 inches/day.

Step 3. Determine replacement water amount by setting the lower allowable limit of available water in the profile. For this example, we will use a typical value of 50% allowable depletion (i.e. only 50% of the water in the root zone will be allowed to be depleted). Therefore, 0.9 inches of water will be required to replace the water used (1.8 inches x 0.50).

Step 4. Determine the amount of irrigation to apply by dividing the amount to be replaced by an irrigation efficiency from Table 3. (There are always losses between water pumped and water actually reaching the crop, such as evaporation, drift, etc.). In this example, we will assume a fairly new center pivot with optimal efficiency, at 88%. Thus, amount to apply = 0.9 inches / 0.88 = 1.02 inches.

Step 5. Determine the frequency of irrigation by dividing the amount of water replaced by water use per day. For example, frequency = 0.9 / 0.3 = 3 days.

Step 6. In this example, it would be necessary to apply 1.02 inches every 3 days to maintain 50% available water in the Tifton loamy sand soil profile for cotton in the 3rd week of bloom. Any rainfall received would be subtracted from the amount to apply.

It is important to note that typically an application amount greater than 0.75 inches results in results in runoff. This means that you will lose any addional water over 0.75 inches, thus it is recommended that you not exceed this amount in any one single application. It is more beneficial for the crop if the required 1.02 inches were split into two applications of 0.51 inches every 1.5 days. If you have a pivot so large that it cannot make a round through the field in the calculated split time it is recommended that you apply the minimum amount that required for the pivot to travel around the field as quickly as possible, and repeat this step as often as needed to reach the

required irrigation amounts. Basically in most instances more frequent irrigation applications with lower rates are recommended.

Intervals for most of the season will be 3 to 4 days for coarse textured sand, 4 to 6 days for more productive loamy sand and sandy loam, and 5 to 8 days for fine textured sandy loam or clay soils. A 4 to 6 day interval will fit a majority of the situations.

Table 2. Examples of Available Water Holding Capacities of Soils in the Coastal Plain of Georgia.

Soil Series	Description	Intake (Inches/Hr) for Bare Soil*	Available Water Holding Capacity (inches/Ft)
Faceville	Sandy Loam, 6-12" Moderate intake, but rapid in first zone	1.0	1.3
Greenville			1.4
Marlboro			1.2-1.5
Cahaba	Loamy Sand, 6-12" Loamy subsoil, rapid in first zone, moderate in second	1.2	1.0-1.5
Orangeburg			1.0-1.3
Red Bay			1.2-1.4
Americus	Loamy Sand, 40-60" Rapid permeability	2.0	1.0
Lakeland			0.8
Troup			0.9-1.2
Norfolk	Loamy sand, 12-18" Rapid permeability	1.3	1.0-1.5
Ochlocknee			1.4-1.8
Dothan	Loamy sand and sandy loam, 6-12" Moderate intake	1.0	1.0-1.3
Tifton			0.8-1.0
Fuquay	Loamy sand, 24-26" Rapid permeability in first zone, moderate in second	1.5	0.6-0.8
Lucy			1.0
Stilson			0.9
Wagram			0.6-0.8

* Increase soil infiltration rate in field where conservation tillage methods are used.

Table 3. Examples of Application Efficiency Values for Various Irrigation Systems.

Type Irrigation System	Application Efficiency	
	Attainable	Expected
Center Pivot		
With Impact Sprinklers	85	75-90
With Spray-type Sprinklers	95	75-95
Lateral Move with Spray-type Sprinklers	95	75-95
Micro-Irrigation		
Subsurface drip	95	75-95
Micro-Spray	95	70-95
Trickle	95	70-95
Moving Big Gun	75	60-75

Irrigation Scheduling

The moisture balance or "check-book" method of scheduling described above is a relatively straight-forward means of determining WHEN to irrigate. This method helps a grower keep up with an estimated amount of available water in the field as the crop grows. The objective is to maintain a record of incoming and outgoing water so that an adequate balanced amount is maintained for crop growth. Other methods of irrigation scheduling include more advanced methods or software such as Irrigator Pro (USDA), soil moisture sensors from companies such as Irrometer, Decagon, AquaSpy, AquaCheck, John Deere Water, etc., the Smart Irrigation Cotton App (www.Smartirrigationapps.org) and the UGA EASY Pan (a simplified pan evaporation device). These devices provide near real-time readings of either soil moisture content or soil water tension in the root zone and can identify when water is needed to replenish the root zone.

As stated earlier, growers with high yield goals should consider implementing a roubust irrigation management plan. However, the grower must evaluate if the implementation of this plan is feasible for their operation. Based on the level of interest the grower should decide if they want to implement a simple plan that they can manage themselves or if they want to go more advanced and either hire a full time employee for irrigation management or hire a consultant to provide recommended irrigation amounts. This decision will be related to farm size, crop produced, and grower investment.

DEFOLIATION, HARVESTING, AND STORAGE

Cotton defoliates much easier when a good boll load has been obtained and available soil nitrogen is nearly depelted by the crop. A cutout, a mature crop is considerably easier to defoliate than one that maintains vigorous vegetative growth and fruiting into harvest time.

Harvest aid products perform several functions, the most important being defoliation, regrowth suppression, and boll opening. Removal of juvenile growth (late season immature foliage) and desiccation of weeds are functions also needed in certain situations. Of the many harvest aid chemicals, none will perform all these functions under all conditions. As a result, combinations

of products are generally recommended and are frequently used, with adjustments in rates and product selection based on crop condition, temperature, calendar date, and equipment availability.

Refer to the tables below: Cotton Defoliation / Harvest Aid Options (as seen in the 2014 Pest Management Handbook) below for information about rates and combinations of harvest aids. Additionally, the UGA Cotton Defoliant Evaluation Program evaluates several product combinations in both early and later planted cotton, and thus different late-season environmental conditions, since 2010. The results of these product comparisons can be found at www.ugacotton.com.

Timing of Defoliation

Timing of Defoliation is critical to insure optimum yield and fiber quality. Several factors can be used to determine the proper time for harvest aid application. The first is the traditional method of counting open and unopen bolls. Defoliation should proceed when least 60 to 75 percent of bolls are open. This method focuses primarily on the "open" portion of the bolls while ignoring the "unopen" portion, which is also important. A second indicator involves slicing bolls with a sharp knife. Bolls are considered mature--and ready for harvest aid applications--when bolls cannot be sliced without "stringing" the lint. In addition, bolls are mature when the seed embryo contains only tiny folded leaves (no "jelly" within the developing seed) and the seedcoat begins to turn yellow or tan. A final method utilized to determine crop maturity is counting nodes above cracked boll (NACB). NACB is determined by counting the number of nodes separating the uppermost first position cracked boll and the uppermost boll that is expected to be harvested. Once the NACB has reached 4 it is generally safe to apply harvest aids. In some cases, when plant populations are low, a NACB of 3 maybe more appropriate. Growers should understand that each method of determining defoliation timing considers different plant characteristics, therefore the use of a combination of these methods would more accurately depict maturity of plants and provide a better indication for optimal defoliation timing.

Ethephon-Boll Ripening Agent

Ethephon is a plant regulator marketed as Prep, Ethephon 6, Pluck, Super Boll and several others. It speeds boll opening, and can also accelerate or enhance defoliation under adverse conditions. In many trials ethephon has approximately doubled the percent of bolls that opened during the 7 to 14 day period following application. Rates of defoliant can generally be reduced when ethephon is used (See tables below). It can occasionally be used in a salvage situation on late cotton to prevent bolls from freezing, although the outcome of the practice may be unpredictable. It can also facilitate once-over harvest with careful scheduling. The normal harvest interval after ethephon application is 10 to 14 days in early to midseason and extends to 17 to 21 days as weather gets cooler.

CottonQuik and Finish, have been available since 1997. In 2006, CottonQuik was replaced with FirstPick. While these products provide significant defoliation, their primary use is the acceleration of boll opening. Both products provide slightly faster boll opening than equivalent rates of ethephon. This faster boll opening is generally observed up to 10 to 12 days after defoliation. After 14 days, there is generally no difference in boll opening between these products and generic ethephon. Routinely, these products should be mixed with other defoliants such as DEF/Folex, Dropp/Free Fall, Ginstar, Aim or ET to achieve better overall performance. Selection of the tank-mix partner should be based on the needs beyond boll opening. For example, in

regrowth situations, Dropp/FreeFall, or Ginstar is an appropriate choice; if only defoliation is needed, options include DEF/Folex (at reduced rates), or several other herbicidal defoliants.

A detailed discussion of crop maturity determinations, timing of application, and harvest-aid chemicals can found in Extension Bulletin 1239 "Cotton Defoliation, Harvest Aids, and Crop Maturity". This publication is available on-line via the UGA cotton web page at www.ugacotton.com. Specific recommendations for tankmixes for various environmental conditions can be found in the Cotton Defoliation / Harvest Aid Options in the Pest Management Handbook.

Harvesting

To do a good job, pickers must be in top condition before they go to the field. Replace any excessively worn or damaged spindles. The alignment and adjustment of spindles to moisture pads and doffers make a considerable difference in the efficiency of a cotton picker. Improperly adjusted spindles will allow some of the cotton to remain on the spindle, causing spindle twist and lower both quality and harvesting efficiency. A well adjusted picker and operation speed will pick cotton with a minimum amount of trash, particularly bark. Picking units and basket grates should be cleaned each time the basket is dumped. The accumulated trash and low-quality fiber should be discarded and not mixed in with the good cotton.

Start pickers after dew dries and stop when dew forms. Use a meter to check the seed cotton moisture. If one is not available, bite the seed. If they crack, the moisture is probably low enough for harvesting. Cotton (lint, seed and trash combined) with a moisture content of 12 percent or lower can generally be harvested and stored satisfactory. Keep harvested seed cotton dry.

Modules

Several factors have an impact on the effectiveness of the moduling system. The most critical is moisture. As stated in the previous section, cotton should be harvested at or below 12 percent moisture. Wet cotton placed in a module lowers grades and creates serious ginning problems, in addition to potentially causing module fires. While the gin process involves drying, gins are mainly designed to remove moisture from lint not from seed. Wet, soft seed greatly reduces gin efficiency and may clog equipment. Cotton with excessive seed moisture may require the gin operator to pass the cotton through the drying system more than once, lowering ginning rate and increasing ginning costs.

Another major factor in the ability of a module to properly store seed cotton is the construction of the module. The tighter the module is packed, the better it sheds rainfall and the less seed cotton is lost during storage, loading and hauling. Modules should contain approximately 14 bales or 21,000 lb of seed cotton. Making modules too large causes handling problems. The top should be rounded so that water sheds after the module is covered. Depressions in which water can collect are sure to cause problems.

Site selection is another important aspect of the moduling system. In Georgia, many fields are not well suited to module placement, so planning should be done before picking begins. If custom operators are used, the responsibility of site selection and preparation should be discussed.

Placement

1. Place modules where water will drain away from the module. Do not place modules at the bottom of water ways.

2. The site should be free of gravel, stalks, and long grass. Prior to placement of modules stalks should be mowed and removed. Grassy areas should also be mowed and clippings removed. This may not seem important; however, grass or bark discounts can more than pay for time spent on site preparation.
3. If possible, place modules in a north/south position so the sun will hit both sides during the day.
4. Do not build modules in one location in the field and move to another. Each time a module is moved, it loses its firmness and shape.

Handling

1. Place modules on a firm surface accessible to trucks in wet weather.
2. Do not till the soil on the truck approach side of the module. The surface in front of the module needs to be firm for the module hauler to retrieve the module without stretching it.
3. Leave enough room in front of the module for the module hauler to get straight with the module for loading.
4. Place approximately 14 bales in the module. An excessive amount of cotton will cause a truck to be overweight, is hard on loading mechanism, and may contact the top of the truck.

Monitoring and Managing Modules

1. Record and monitor the temperature of modules for the first 7 days. If a temperature rise of 20^{o} F or a temperature of 120^{o} F is reached, gin the module as soon as possible.
2. If a storm occurs, check module tarps and remove any water that has collected on top of the module cover.
3. Check tarps for holes and tears. Replace any defective tarp.

New Technology

Both Case and John Deere have developed cotton pickers with on-board capacity to construct modules or something similar. Research is on-going to determine the increased efficiencies associated with these new technologies. Preliminary observations suggest that some types of these pickers may reduce waste, may reduce trash from soil, stubble or grasses, and may preserve some yield and fiber quality characteristics.

CONSERVATION TILLAGE

Conservation tillage practices are employed on about 50 percent of the Georgia cotton acreage. In Georgia, conservation tillage and strip tillage are essentially synonymous. Incentives for such systems include reduced trips over the field, reduced labor and equipment costs, and soil and water conservation. After several years in reduced tillage, a slight buildup in overall organic matter often occurs, with significant increases in the upper half inch at the soil surface.

Success in conservation tillage requires a commitment to "make it work." Not surprisingly, there are pockets in the state of devotion to this methodology and adoption of the technology seems to grow more rapidly in these areas. Farmers gain confidence from watching successes on neighboring farms, and thus, are willing to attempt a significant change in production practices. Successful conversion to conservation tillage is rarely piecemeal, it requires a total change in equipment and management. Required equipment includes a strip till unit, sprayer, and hooded sprayer or high residue cultivator.

Historically, the greatest challenges of reduced tillage systems have been stand establishment and weed control. Strip tillage implements have eased the complications of obtaining a stand by creating an environment similar to conventional seedbed preparation. For reduced tillage systems, burndown herbicides replace preplant tillage as the means of eliminating vegetation.
The increased reliance on herbicides requires careful selection of products and rates as well as timely application.

Strip Till Equipment
Strip till equipment includes tillage implements which provide a narrow zone of tillage in the crop drill. These implements remove weed or cover crop debris, subsoil under the row, and provide a reasonable seedbed for planting cotton. Several brands are available, and possible options include variations in coulters and rear closing/mixing tools.

General Problems
Conservation tillage systems are not without problems. Success demands careful planning and management. In most situations, growers should begin a year in advance in preparations for changes to conservation tillage. Planting into residues or untilled surfaces requires use of specialized equipment and increased reliance on agrichemicals. Inclusion of cover crops may increase management and expense. In addition, cover crops may drain needed moisture in a dry year or retain excess moisture in a wet spring. Reduction in tillage may cause changes in pest complexes, for example, proliferation of certain perennial weeds. Weed control is further complicated by the inherent inability to incorporate dinitroaniline herbicides, which provide the backbone of annual grass and small seeded broadleaf control in conventional systems.

Soils
The presence of covers often results in slightly cooler soil temperatures, which may delay planting and/or increase seedling disease. Reduced tillage generally improves soil moisture, although the presence of covers may deplete soil moisture in a dry spring or conversely, retain excessive surface moisture in a wet spring. Either situation may delay or hinder cotton stand establishment. Though few trials have documented advantages of particular cultivars in conservation tillage, potential stresses of cool temperatures suggest the need for planting cultivars with good early season vigor.

Long term reduced tillage may cause compaction in some soils, but in others, soil tilth may increase. Significant increases in organic matter require continuous conservation tillage for at least 3 to 5 years. Shallow fall disking or chisel plowing smooths field surfaces, providing a level seedbed for subsequent spring planting of cotton. Long term use of controlled traffic patterns may eliminate the need for subsoiling every year.

Cover Crops
Use of seeded covers increases cost and management but with benefits of added surface residues, soil and water conservation, wind protection, and possibly grazing, seed production, or N fixation. For compliance purposes, surface litter must provide 30 percent cover of the soil immediately after planting to qualify as "conservation tillage." Cover establishment
can be accomplished by aerial seeding, spreading with fertilizer, or standard drill seeding in the fall. Cover crop establishment methods which do not include fall tillage, favor establishment of wind-dispersed, cool season weeds such as horseweed. In crops such as soybeans or cotton, aerial seeding prior to leaf drop aids in cover crop establishment. Seeding rates can be lower than used for forage or grain production; however, many growers suggest that full seeding rates are needed

to gain competitive advantage over weeds. In some situations, fallow or natural weed cover may be an economical alternative, provided they develop a sufficient winter cover.

Generally, small grain cover crops are easier to deal with than legumes. With high fertility, however, small grains may produce excessive growth, thus increasing problems with strip tillage and planting equipment and requiring slightly higher N rates (in cotton). In lower portions of the state, double crop wheat works in some years, although later planted cotton is at risk to early frost. Among the small grains, rye is probably the most adaptable. It is easiest to kill, easy to establish, and provides aggressive fall growth. In some instances, rye may provide too much vegetative growth and thus wheat may be a better choice. Ryegrass is extremely difficult to eliminate in the spring with burndown herbicides and should not be planted as a cover.

Though they may offset need for fertilizer N by about 30 lb/A, legumes pose several challenges. Legumes are often difficult to kill with burndown herbicides, and the release of ammonia during decomposition of green matter may injure cotton seedlings unless the cover is killed 2 weeks or more prior to planting. Legumes are also a host for cutworms and nematodes, the latter of which is a serious concern as increases in cotton acreage limit rotation. Most legume/conservation tillage systems have involved hairy vetch and crimson clover. In southern extremes and with early seeding varieties, crimson clover may work well in a reseeding program; in other words, clover may mature and produce seed prior to the time cotton should be planted.

Cover crops or weeds should be terminated with burndown herbicides 2 to 3 weeks before seeding cotton. Partial or strip killing of covers is usually not effective because of the competitive effects of the cover on the young cotton crop. Application accuracy of burn down sprays is facilitated by foam markers, light bars, or guidance systems. Termination of cover crops should be timed to limit excessive growth. This is of special concern with aggressive covers such as rye. Though research is not very precise on the matter, rye should be terminated before it reaches 3 to 4 ft tall, other small grains before they exceed 2 to 3 ft. The key is to desiccate the cover to prevent excesses in dry matter production and complications with strip tillage and soil/seed contact at planting.

Fertility

Because of limited opportunity to correct problems, a move into conservation tillage should begin only after establishing proper pH and fertility. Surface applications of lime and fertilizer are adequate for maintaining nutrient levels in reduced till systems. Starter fertilizers may have greater utility in conservation tillage because of cooler or compacted soils and the inability to thoroughly mix fertilizer amendments. Nitrogen fertility must be integrated with cover crop management--increase N rates for small grains, decrease for legumes--and petiole testing may be even more valuable in conservation tillage than in conventional tillage systems.

Strip Tillage/Planting

Achieving an adequate crop stand is foundational for successful cotton production. In conservation systems, strip tillage and planting equipment must effectively operate in surface litter and narrow, tilled zones to place cotton seed in firm contact with moist soil at a desired depth. Fortunately, manufacturers and farmer-innovators have developed numerous implements for planting in reduced tillage situations.

Strip tillage and planting may be performed in the same or separate operations, with advantages for either approach. If both are performed in the same pass, there are fewer tracking problems

and obvious savings in equipment and labor. Delaying planting 10 days or more after strip tillage reduces problems associated with litter decomposition and allows for moisture recharge of the tilled seedbed.

Rain or timely irrigation overcomes poor planting technique and poor soil/seed contact. Planting in a depression should be avoided because of potential problems with preemergence herbicide injury, postemergence weed control, and harvest. Standard strip tillage practices are not readily suited to establishment of raised beds and smooth row shoulders. However, a few growers have had success with fall bedding followed by cover seeding in order to create beds for the subsequent planting of cotton.

Insect Management

Insect management in conventional and reduced tillage systems is similar for most insect pests. However, differences do exists, most notably is the increased risk of cutworms in reduced tillage systems, especially if a legume cover crop is used. To reduce the risk of cutworm attack cover crops or winter weeds should be **controlled at least three weeks prior to planting**. No green vegetation should be present at planting, as it may serve as a reservoir host for various insects which may infest cotton. If the risk of cutworm infestation is high (i.e. green vegetation present, legumes cover crop, etc.), consider banding a cutworm insecticide such as a pyrethroid behind the planter as a preventive treatment. Increased infestations of false chinch bugs are sometimes observed in reduced tillage systems when a timely burndown herbicide was not applied. Grasshoppers are also more common in reduced tillage systems. We tend to observe fewer thrips in conservation tillage systems, but a thrips management program will still be needed. As fields remain in conservation tillage for several years, fire ants (beneficial) tend to increase.

Disease Management

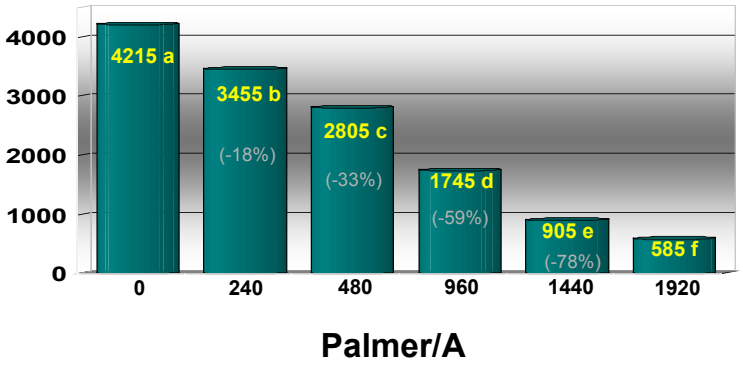
Cooler temperatures and decaying vegetation contribute to increased potential for seedling disease in conservation tillage. Delaying planting or separating strip tillage and planting typically results in warmer, more favorable conditions and thus may aid in stand establishment in reduced till systems.

The interaction of covers with nematodes is not fully understood, but the preference of nematodes for certain legumes raises questions about their long term use in conservation tillage cotton. This is especially true for clovers and vetches.

WEED MANAGEMENT IN COTTON

Effective weed management is one of many critical components of successful cotton production. Because cotton does not compete well with weeds, especially early in the season, a given number of weeds will reduce cotton yield more than corn or soybean yield (Figure 1). Weeds also may interfere more with harvesting of cotton and can reduce lint quality because of trash or stain.

Figure 1. Irrigated Cotton Seed Yield vs Glyphosate-Resistant Palmer Amaranth Density.



Crop Rotation

Crop rotation aids in the management of nematodes and diseases. Additionally, it can be a significant component of a weed management program. Crop rotation allows the potential use of herbicides with different modes of action on the same field in different years. By rotating cotton with other crops and selecting an herbicide program for the rotational crop that effectively controls the weeds that are difficult to control in cotton, one can reduce the impact of problem weeds. *Crop rotation and properly planned herbicide rotation are also critical components of an herbicide resistance management strategy.*

When selecting an herbicide program for crops preceding cotton, consider rotational restrictions for the various products. This information can be found on herbicide labels. Many of the commonly used herbicides in other crops do not carry over to cotton. However, labels for products listed below contain significant rotational restrictions for cotton.

Active ingredient	Some of the products containing the active ingredient
chlorsulfuron	Finesse Cereal and Fallow, Finesse Grass and Broadleaf, Report Extra
imazaquin	Scepter
imazapic	Cadre, Impose, Nufarm Imazapic
imazethapyr	Authority Assist, Extreme, Lightning, Matador, Optill, Pursuit, Tackle, Thunder
sulfentrazone	Authority Assist, Authority First, Authority Maxx, Authority MTZ, Authority XL, Sonic, Spartan, Spartan Charge

Similarly, several cotton herbicides including Cotoran, diuron, Envoke, fomesafen (Reflex, other), Staple, Pyrimax, and Suprend have significant rotational restrictions to some other crops.

Cultivation

Cultivation traditionally was a critical component of cotton weed management; however, the process all but disappeared with the commercialization of Roundup Ready technology. However,

glyphosate-resistant Palmer amaranth has forced many growers back into cultivating with over 40% of the crop cultivated from 2011-2013 and over 25% of the crop cultivated in 2014. Cultivation can be used to effectively manage small Palmer amaranth, and other weeds, between cotton rows. If possible, cultivate prior to Palmer amaranth reaching 3 inches and tropical spiderwort reaching 2 inches; also avoid rainfall or irrigation for at least 48 hours after cultivating. *Cultivation can be an effective component of an herbicide resistance management strategy.*

In addition to controlling weeds, cultivation may improve early season cotton growth in tight or crusted soils. On most soils, however, cultivation is of no value beyond weed control. For growers who are able to eliminate cultivation, this reduces equipment and labor demands and the subsequent weed flushes, moisture loss, and root damage associated with the practice.

Planning a Herbicide Program

Before selecting herbicides, one should know what weeds are present or are expected to appear, the soil characteristics (such as soil organic matter and texture), the capabilities and limitations of the various herbicides, the weeds controlled by these herbicides and how to best apply them. Application rates for soil-applied herbicides depend on soil texture, organic matter content, and irrigation program. Failure to adjust application rates for soil characteristics and irrigation scheduling may result in poor weed control or severe crop injury.

Weed Mapping

The first step in a weed management program is to identify the problem. This is best accomplished by weed mapping. Survey the fields each fall and record on a field map the species and population levels present. Species present in the fall will likely be the predominant problems during the following year. You can better plan an herbicide program if you know ahead of time what species to expect. Additionally, by referring to weed maps over a period of two or three years, you can detect shifts in the weed populations and make adjustments in the herbicide program to deal with changes that occur. Proper weed identification is critical as different weed species respond differently to various herbicides.

In-Season Monitoring

During the first 6 weeks after planting, check fields every 3- to 5-days to determine the need for postemergence herbicides or cultivation. From the sixth week through canopy closure, check fields weekly to evaluate the success of the weed management program and to determine the need for additional control measures. If weeds are controlled for the first ten weeks, any later emerging weeds will seldom become problems for harvest but could increase the number of seed being added to the seedbank.

Herbicide Resistance Management

Herbicide resistance in weeds is not a new problem. The threat posed by herbicide resistance has, however, recently been elevated to a much higher level. Palmer amaranth resistant to glyphosate, ALS-herbicides (Staple, Envoke, Cadre), DNA-herbicides (Treflan, Prowl), and/or atrazine have been confirmed in most major agronomic producing counties in Georgia. Additionally, common ragweed, goosegrass, horseweed, johnsongrass, and ryegrass resistant to glyphosate are scattered across the country.

In previous years, growers with herbicide-resistant weeds were fortunate to have new herbicides (specifically, new mechanisms of action) come into the marketplace before the problem became

overwhelming. That is not the case for the foreseeable future; new modes of action are simply not on the horizon. It is therefore imperative that growers take herbicide resistance management very seriously in an attempt to maintain usefulness of current products and technologies.

What Causes Resistance?

Herbicide resistance is the inherited ability of a biotype of a weed to survive and reproduce following exposure to a dose of herbicide normally lethal to the wild type. Herbicides do not cause resistance. Rather, herbicides select for resistance naturally occurring in the population. Greater reliance on a particular herbicide, or group of herbicides, with the same mode of action puts greater selection pressure on any resistant individuals that may be in the population. A shift to reduced tillage production, especially in the late 1990's, has led to greater reliance on herbicides and greater resistance issues.

Resistance Management Strategies

There are two prerequisites for resistance. First, one or more individuals possessing genes conferring resistance must be present in the population. Second, selection pressure resulting from extensive use of an herbicide to which these rare individuals are resistant must be exerted on the population. Growers have no way to know if a few plants carrying resistance are present on their farm. Hence, the only way to prevent a buildup of resistant plants is to utilize management systems that reduce selection pressure on any resistant individuals that may be present.

Nearly all of Georgia's cotton is planted to Roundup Ready varieties. A similar percentage of soybeans and an increasing percentage of corn are also being planted to Roundup Ready varieties. In the past, growers relied almost exclusively on glyphosate for weed control. Extensive reliance on a single mode of action (the mechanism by which the herbicide kills susceptible plants) over that much acreage puts tremendous selection pressure on resistant weeds present in the population and this is one of the reasons glyphosate-resistant Palmer amaranth currently dominates our agronomic landscape.

Use of PPO herbicides such as Reflex and Valor SX has increased dramatically in cotton and other crops to manage glyphosate-resistant Palmer amaranth. There is concern that the use of these herbicides repeatedly will result in selection for PPO-resistant biotypes. Similarly, over-reliance on Liberty in LibertyLink, GlyTol/Liberty Link or WideStrike cotton as the primary mode of action for weed control will select for resistance to Liberty.

It is absolutely essential that herbicide programs 1) are diverse in mode of action and 2) are integrated with other cultural control practices (hand-weeding, tillage, cover crops, crop rotation) in order to reduce selection pressure for resistant weeds. Cotton growers can incorporate the recommended herbicide diversity in modes of action into a glyphosate-based or Liberty-based management program by using soil-applied residual herbicides, tank mixing another herbicide with glyphosate or Liberty when applied postemergence, and using alternatives to glyphosate or Liberty at layby. Use of full rates of glyphosate or Liberty, even in tank mixes, is required.

Burndown in No-Till or Strip-Till Cotton

Winter weeds should be killed at least 2 weeks before planting while cover crops should be killed at least 1 week before planting. With cover crops adequate rainfall or irrigation occurring between burndown and planting is usually needed. Burndown herbicides are outlined in Appendix V.

If no-tilling or strip-tilling into natural cover (i.e., winter weeds), the need for an early burndown treatment will depend on the weed species present and the size of the weeds. An early burndown is normally advantageous, especially if ryegrass, cutleaf eveningprimrose, horseweed, wild mustard, wild radish, or curly dock is present. ***For those applying 2,4-D or dicamba products, applications should be completed prior to March 1.***

Cutleaf eveningprimrose and wild radish have been difficult weeds to kill in strip-till fields. The most effective and economical option for controlling primrose is an application of 2,4-D alone or mixed with any glyphosate mixture (such as Roundup + Valor) at least 30 days before planting. For primrose, 2,4-D at 8 to 12 oz/A of a 3.8 lb/gal formulation is sufficient; however, rates of 1.0 to 1.5 pt/A are needed for wild radish and 2 pt/A is need for glyphosate-resistant horseweed. Clarity (dicamba), an option for glyphosate-resistant horseweed will also control primrose and wild radish although somewhat less effective on primrose than 2,4-D.

For growers who do not want to put 2,4-D or dicamba in their sprayers, Liberty or a combination of glyphosate plus Valor are options to provide fair (70 to 80%) control of pre-blooming primrose. For wild radish, glyphosate mixtures containing Harmony Extra are effective. After primrose and radish are in full bloom, good control can be obtained with a combination of paraquat plus Direx. Liberty can control blooming primrose under warm conditions but will not control immature wild radish.

Before applying any herbicide prior to cotton planting review the table below and the respective product labels for uses and plant back restrictions.

Plant back restrictions and comments for cotton burndown herbicides.

Burndown Selection	Time Interval Before Planting	Special Comments
Roundup or Paraquat	anytime prior to planting	
2,4-D	unknown for many brands; 30 d for Barrage HF and Salvo 5 at proper rates	label suggest cotton can be planted after 2,4-D has dissipated from the soil
Direx	no till: 10 d; strip till after application and before planting: 0 d; *(special state label allow these options)*	Do not exceed 1 qt/A, see label for rate on your soil. Suggest avoiding PRE if used preplant within 12 days of planting.
Harmony Extra/Express	at least 14 days	
Valor	strip-till after applying Valor but before planting: ≥10 d; no-till with <30% residue: 28 d and 1" rain; no-till with >30% residue: 21 d and 1" of rain	Do not exceed 2 oz/A if planting within 30 days. **Add 7 additional days to no-till plant back restrictions if Reflex (or generic) will be applied PRE.**
Goal	at least 30 d	need 3 rainfalls each at least 0.25 inch
Leadoff	at least 30 d for 1.5 oz/A	one inch rain suggested

Weed Management in Roundup Ready Flex Cotton

Planting into a Seedbed Free of Palmer amaranth

The greatest pest management challenge for growing cotton is making sure Palmer amaranth is not emerged when planting. Options are available to prevent Palmer amaranth from being up at planting including tillage and herbicides. For conservation tillage, the use of Valor and/or Direx preplant is critical. Valor is the most effective residual herbicide while Direx plus paraquat (Gramoxone, others) offers the most effective control of emerged plants (Table 1). Follow the appropriate plant back restrictions with these herbicides as noted in Table 2. For conventional tillage production, tillage alone can be effective but the single most effective program would be a split Reflex system where part of the Reflex (plus Treflan or Prowl) is preplant incorporated into moist soil prior to planting (Table 1).

Table 1. The most effective options to eliminate emerged Palmer amaranth at planting.

Prior to Planting	
CONVENTIONAL TILLAGE	**CONSERVATION TILLAGE**
Option 1 **Reflex 12 oz/A + Prowl/Treflan** *apply preplant incorporated 1 to 2 inches deep (preferably within 7 days of planting)* **Option 2** **Keep clean with tillage or herbicides**	**Option 1** **Valor with glyphosate or paraquat** *(Palmer < 1" and more than 10 d before planting)* **Option 2** **Valor + Direx + paraquat** *(Palmer 1 to 5" and more than 10 d before planting)* **Option 3** **Direx + paraquat** *(Palmer ≤ 5" and less than 10 d before planting)*

Table 2. Plant back intervals for Valor or Direx applied at burndown.

Herbicide	Time Interval Before Planting	Special Comments
Valor	strip-till after applying Valor but before planting: ≥10 d no-till with <30% ground residue: 28 d and 1 inch of rain no-till with >30% ground residue: 21 d and 1 inch of rain	Do not exceed 2 oz/A if planting within 30 days. ***If applying Reflex (or generic PRE), add an additional 7 days to no-till planting intervals.***
Direx	no till: 10 d strip till after application and before planting: 0 d	Do not exceed 1 qt/A, see label for rate on your soil. Suggest avoiding PRE if applied preplant within 12 d of planting.

Selecting the Ideal Preemergence (PRE) Herbicides

Residual at-plant herbicides are required to grow all cotton cultivars and Georgia research consistently shows that the key is to actually select two effective residual herbicides and apply them in mixture with paraquat (Gramoxone, etc.) within 24 hours of planting. Reflex is the most effective Palmer amaranth herbicide that can be used at planting. It requires very little rainfall/irrigation to activate and it will lay on the soil for several weeks with minimal degradation. Thus in severely infested Palmer amaranth fields, a Reflex tank mixture is in order.

Georgia research has shown Reflex plus Warrant or Reflex plus Direx to be consistently effective (Table 3). When comparing Warrant vs Direx as a Reflex tank mix partner one should consider 1) Warrant offers more residual Palmer control and will sit on the soil longer waiting on an activating rainfall but 2) Direx offers the greatest ability to control emerged weeds, especially Palmer amaranth. A three-way combination of Reflex plus Warrant plus Direx rarely provides greater residual control when compared to the two-way combinations but may provide more control of emerged plants at planting. Additionally for the grower who has been frustrated with Reflex injury, a mixture of Warrant plus Direx has proven to be a very effective alternative. Always, include paraquat and adjuvant with the PRE if any Palmer is emerged.

Table 3. Most effective herbicide options to apply preemergence (PRE) when planting RR cotton.

Preemergence Option	Comments
1. Warrant + Reflex 2. Direx + Reflex 3. Warrant + Direx	1. Cotoran can be used to effectively replace Direx in fields with minimal Palmer infestations or for improved control of other broadleaf weeds. 2. Use 12 oz/A of Reflex for most soil types except when using the split reflex program where 8 to 10 oz/A PRE following 12 oz/A PPI is in order. 3. Warrant use rate is typically 48 oz/A unless planting into very light soils where 32 to 40 oz/A would be in order. 4. Direx use rate is typically between 10 and 20 oz/A with lower rates on lighter soils and in conditions where heavy rainfall/irrigation is expected.

Replanting

Should replanting be necessary where soil-applied herbicides have been used, it is best to run the planter back in the original drill without any soil preparation if soil conditions permit. If reworking the seedbed is necessary then the following procedures are suggested:

Strip tillage: Rerun the strip till rig which should include ripper shanks followed by planting. After replanting, apply a PRE herbicide mixture that includes both a non-selective herbicide to control emerged weeds/cotton and a residual herbicide. The residual herbicide should be different chemistry than that used with the original planting. It is likely the residual herbicide used with replanting may offer limited residual Palmer control; thus, the first early POST application must be made quickly after replanting in a Roundup Ready system (likely 10 d).

Conventional Tillage: For growers who do not have strip tillage implements, use shallow tillage such as light disking. Do not re-bed without first disking. Re-bedding without disking can lead to severe injury. The amount of time that has passed and the amount of rainfall that has occurred between herbicide applications and replanting will determine the need for additional herbicides. In general, additional herbicides will be needed when replanting but one should switch residual herbicide chemistry from that used during the first planting.

Glyphosate, paraquat, or Liberty must be included to control emerged weeds and cotton when replanting. Paraquat (Gramoxone, others) or Aim will control small emerged cotton. Liberty is also effective controlling cotton as long as it is not a cotton cultivar tolerant to Liberty.

Timing of Roundup Application and Brands Used

Brands of glyphosate with specific labeling for Roundup Ready Flex cotton may be applied overtop or directed to Roundup Ready Flex varieties any time from cotton emergence until seven days prior to harvest. The maximum rate for any single application between crop emergence and the 60% open boll stage is 1.13 pounds a.e. A total of 4.5 pounds a.e. can be applied during this

time frame. An additional 1.55 pounds a.e. per acre can be applied from the 60 percent open boll stage until seven days prior to harvest.

A number of brand names and formulations of glyphosate are available. Most currently available products are formulated as isopropylamine salts or potassium salts, although a few products are formulated as dimethylamine salts or as mixtures of ammonium salt plus potassium salt or isopropylamine salt plus potassium salt. Products vary in their concentration of active ingredient. Labels for some brands direct the user to add nonionic surfactant. Other brands are "loaded formulations," meaning additional surfactant is not necessary. Read the label of the brand used to determine need for surfactant.

Over-the-Top Tank Mixes with Glyphosate

In general, growers should focus on mixing Staple, Dual Magnum, or Warrant with glyphosate and making two topical applications during the season. These herbicides plus additional glyphosate tank mix partners are discussed in depth below.

Assure II, Fusilade DX, Poast, Poast Plus, or Select Max can be mixed with glyphosate to control volunteer Roundup Ready corn.

Dual Magnum can be applied overtop from emergence until 100 days prior to harvest. Crop injury from glyphosate plus Dual overtop is typically minor, with necrotic speckling noted on leaves contacted. This injury is temporary; no speckling on later-emerging leaves, no stunting, and no adverse effect on yield or maturity have been noted. The exception has been when 1) additional adjuvants or some insecticides are included in the mixture 2) when applications are made when heavy dew is on the cotton or 3) when the weather is extremely hot and humid.

Mixing Dual Magnum with glyphosate will have no effect on emerged weeds by glyphosate. However, if timely rainfall/irrigation for activation is received, Dual Magnum can provide residual control of most annual grasses (suppression of Texas millet), pigweed species (including Palmer amaranth), doveweed, and tropical spiderwort (control for 18 to 30 days often noted), and suppression of yellow nutsedge and spreading dayflower. Dual Magnum mixed with glyphosate will likely broaden the window of application for directed herbicides on Palmer amaranth.

Generic brands of metolachlor are available. Growers should be aware that some generics are not the same as Dual Magnum. Metolachlor is a mixture of four stereo-isomers. Two of the isomers (referred to as *S*-metolachlor) are herbicidally active whereas the other two isomers (referred to as *R*-metolachlor) have little herbicidal activity. Labels for most generic brands refer to the active ingredient as "metolachlor", meaning it is the mixture of active and inactive isomers. The active ingredient in Dual Magnum is *"S*-metolachlor", the active isomers. Georgia research has shown that "metolachlor" products applied at the same rate as "S-metolachlor" products will likely not provide the same length of residual control. The "metolachlor" product use rate would need to be increased by 50 percent to get the same activity as "S-metolachlor".

Do not tank-mix Dual Magnum (or any generic) and Staple LX.

Envoke at 0.1 oz of product per acre can be mixed with Roundup brands of glyphosate, Touchdown HiTech, or Touchdown Total and applied overtop of Roundup Ready Flex cotton from the 5-leaf (prefer 7-leaf) to the 12-leaf stage according to the label. Injury and plant stunting has consistently been observed; thus, UGA recommends this application only as a directed

application. Envoke mixed with glyphosate will improve control of nutsedge, hemp sesbania, and larger *Ipomoea* morningglory (will not enhance smallflower morningglory control) compared to glyphosate alone.

Sequence is a prepackaged mixture of the potassium salt of glyphosate and *S*-metolachlor. Applied at 2.5 pints per acre, Sequence is equivalent to 0.7 lb a.e. of glyphosate plus 1 pint of Dual Magnum.

Staple LX or Pyrimax can be mixed with glyphosate and applied overtop of Roundup Ready Flex cotton from the cotyledonary stage until 60 days prior to harvest. Rates are typically applied at 1.3 to 1.9 fluid ounces when tank mixed with glyphosate, but with glyphosate-resistant Palmer amaranth being so common a rate of 2.6 fluid ounces would be in order for Palmer amaranth between ½ and 1.0 inch in height. Salvage applications do allow increased rates up to 3.8 fluid ounces (see labels) and would be needed for larger pigweed; injury is a concern when using salvage rates.

A mixture of glyphosate plus Staple or Pyrimax will improve control of hemp sesbania, morningglory (except tall morningglory), spreading dayflower, tropical spiderwort, and glyphosate-resistant Palmer amaranth (assuming it is not also ALS-resistant) as compared with glyphosate alone. Staple or Pyrimax will give some residual control of susceptible weeds such as pigweed species. Palmer amaranth resistant to these products and other ALS inhibitors is present in MANY Georgia fields.

Compared to glyphosate alone, a mixture of glyphosate plus Staple or Pyrimax may injure cotton. Applied overtop, temporary yellowing of the cotton bud is likely. Research has demonstrated that cotton recovers quickly, and there is seldom an adverse effect on yield or maturity. On occasion, however, moderate to severe injury with this mixture may occur. The potential for significant injury appears to be greater when the herbicide is applied during or shortly before a period of cool temperatures and when dew is present on the cotton at time of application. Other stresses such as wet weather, seedling disease, or thrips damage may worsen injury.

Warrant can be used in a manner similar to Dual Magnum. Warrant plus glyphosate can be applied topically after cotton is completely emerged but before first bloom. However, UGA research suggest applications be made from emergence up until the 7 leaf stage of cotton development to avoid severe injury that can occur with applications after the 7 leaf stage. Crop tolerance is similar to that with Dual Magnum as long as applications are made prior to 7 leaf cotton. Two applications of Warrant may be made during the season such as one PRE application followed by a POST application or two POST applications.

Do not tankmix Warrant with Staple.

Warrant and Dual Magnum are similar in many ways but there are some distinct differences. Initial research suggest Dual Magnum is much easier to activate and provides immediate Palmer amaranth control once it is activated while Warrant requires a few days to become active after rainfall/irrigation as the encapsulation is degrading. However, Warrant is far more effective when herbicides lay on the soil 7 to 14 days waiting for rainfall/irrigation. Also, Warrant can be applied preemergence to cotton while Dual Magnum can cause severe cotton injury when applied preemergence to cotton. Neither product should be applied preplant.

Layby Applications:
In nearly all fields, Palmer amaranth is the dominant species present and an application of diuron (Direx, other) + MSMA or Suprend + MSMA is suggested as these are the most effective options; only Gramoxone + diuron (under hoods) is more effective. One common weakness of diuron + MSMA is the lack of morningglory control when plants are larger than three inches. When both Palmer amaranth and morningglory need to be controlled then one should mix either 1) Aim, 2) Envoke, or 3) ET with diuron + MSMA; make certain cotton is large enough for selected product.

If Palmer amaranth is not problematic at layby but grasses are the predominant problem and they are larger than one inch, glyphosate will be the more effective option. Potential partners with glyphosate to post-direct include Aim, Caparol, diuron, Dual Magnum, Envoke, ET, Staple, Suprend, Valor and Warrant. Each of these mixtures will be discussed below.

Aim and ET mixed with glyphosate will improve control of larger morningglory and Florida pusley compared to glyphosate alone. Additionally, Aim will provide excellent control of emerged tropical spiderwort that is four inches or less. Cotton should be at least 20 inches tall, and the spray must be directed precisely to the woody portion of the stem. Spray contact with green stem tissue will cause injury. Neither product provides residual control.

Caparol or Diuron mixed with glyphosate improves morningglory and pigweed control compared to glyphosate alone. Caparol at 2 pints or diuron (Direx 4 L, other) at 1.5 pints will provide some residual control of small-seeded broadleaf weeds, such as pigweed, if activated by rainfall/irrigation. Diuron is usually more effective on Palmer amaranth than Caparol. Cotton should be at least 12 inches tall before directing Caparol or diuron at these rates. Occasionally, mixing Caparol or diuron with glyphosate will reduce grass control by glyphosate. This is most likely to occur under dry growing conditions with large grasses. Do not reduce the glyphosate rate when applying these mixtures.

Dual Magnum mixed with glyphosate will have no effect on control of emerged weeds by glyphosate. However, if Dual Magnum is activated by rainfall/irrigation, it will provide residual control of annual grasses (Texas millet is only suppressed), pigweed species, doveweed, and tropical spiderwort, and suppression of yellow nutsedge. This herbicide mixture can also be directed to cotton from 3 inches tall until 80 days prior to harvest. Dual Magnum should be applied only once during a cotton crop.

Envoke mixed with glyphosate will improve control of nutsedge, hemp sesbania, and larger *Ipomoea* morningglory (will not enhance smallflower morningglory control) compared to glyphosate alone. Cotton should be at least 6 inches tall. Preliminary research indicates Envoke has more residual activity on broadleaf weeds than originally thought but residual activity is not effective in controlling Palmer amaranth. Palmer amaranth resistant to Envoke and other ALS inhibitors is present in many Georgia fields.

Fierce can be used in the same manner as flumioxazin (Valor, etc.) discussed just below. It gives excellent residual control of grasses and broadleaf weeds once activated.

Staple LX or Pyrimax mixed with glyphosate will improve control of hemp sesbania, morningglory (except tall morningglory), spreading dayflower, tropical spiderwort, and glyphosate-resistant Palmer amaranth that is non-ALS resistant as compared with glyphosate alone. Residual control of susceptible weeds will also be provided from these products.

Suprend is a mixture of the active ingredients in Caparol and Envoke. Suprend mixed with glyphosate will improve control of larger morningglory, nutsedge, and small pigweeds. It also will provide residual control of susceptible broadleaf weeds. Cotton should be at least 8 inches tall when directing Suprend.

Valor SX mixed with glyphosate will improve control of doveweed, larger morningglory, Florida pusley, tropical spiderwort and glyphosate-resistant Palmer amaranth compared to glyphosate alone. Outflank, Panther, and Rowell have the same active ingredient as Valor. Cotton should be at least 18 inches tall and the stem should be completely "woody" before this combination is precisely directed to the bottom 1- to 2-inches of the cotton stem. Add nonionic surfactant at 1 qt per 100 gal spray solution if glyphosate brand requires adjuvant. DO NOT use crop oil concentrate, methylated seed oil, organo-silicone adjuvants, or any adjuvant product containing these. Valor, if activated by rainfall, will provide excellent residual control of pigweed species including Palmer amaranth, Florida pusley, and many other broadleaf weed species. Valor has a very favorable rotational package, see label.

Warrant can be mixed with glyphosate and directed to cotton up to first bloom. Warrant will not control emerged weeds, but if activated, will provide residual control of annual grasses and small-seeded broadleaf weeds, including Palmer amaranth and tropical spiderwort. Warrant can only be applied twice during a cotton crop.

Zidua can be mixed with glyphosate and directed to cotton after the 8-leaf stage through bloom; do not apply topically. Zidua will not control emerged weeds, but if activated, will provide residual control of annual grasses and small-seeded broadleaf weeds, including Palmer amaranth.

Weeds Difficult to Control with in a Roundup Ready System

Bermudagrass: The most effective method to manage severe bermudagrass populations are fall applications of glyphosate (sequential applications 10 d apart and at least 10 d before frost) followed by glyphosate or postemergent graminicides in the following crop. Postemergence graminicides (Select, Select Max, Fusilade DX, Assure II) may be more effective than glyphosate in controlling immature bermudagrass with runners less than 6" but a tank mixture of glyphosate plus graminicide would likely be the most effective option when labeled.

Doveweed: Glyphosate will not control doveweed. Dual Magnum will control doveweed well if the herbicide is activated before doveweed germination. Preliminary data also suggest Warrant may also be an effective residual option. Paraquat (Gramoxone, others) applied with a hooded sprayer will control emerged doveweed. And, directed applications of Valor plus MSMA, Valor plus glyphosate, and diuron plus glyphosate appear to be fairly effective on emerged plants.

Florida pusley: Florida pusley can be controlled by glyphosate but ONLY if applied at the full rate when the weed is very small (1" or less) and under ideal conditions; multiple applications are sometimes necessary. One should use a residual herbicide at planting. Treflan, Prowl, Cotoran, diuron, and Warrant control this weed if applied properly and activated by rainfall/irrigation.

Glyphosate-Resistant Common Ragweed: A biotype of common ragweed resistant to glyphosate has been confirmed in North Carolina. If common ragweed is expected, apply Cotoran, Direx, and/or Reflex preemergence. Envoke or Liberty (in tolerant cultivars) can be applied postemergence to control common ragweed.

Glyphosate-Resistant Palmer Amaranth: Palmer amaranth is Georgia's most problematic weed. It is imperative that growers continue to use sound herbicide programs (Table 4, below) but also integrate these programs with other control measures, such as hand-weeding, to remove escapes before seed are produced, deep turning to reduce the number of plants emerging (ideally wait 3.5 to 4 years before repeating), and/or using a heavy mulch cover crop to suppress Palmer emergence in conservation tillage. Also, it is imperative that Palmer amaranth is controlled in crops rotated with cotton, and this should be done with minimal reliance on ALS and PPO inhibitors as well as with Liberty. Because Staple, Reflex, Valor and Liberty are critical in a cotton program to control glyphosate-resistant Palmer amaranth, it is a grower's best interest to prevent or at least slow further selection for resistance to these herbicides.

Table 4. Managing glyphosate-resistant Palmer amaranth in RR Flex cotton.[1]

Prior to Planting	Preemergence (PRE)[2]	POST 1 at 13 d after PRE[3]	POST 2 at 14 d after POST 1[3]	Layby at 18 d after POST 2[3]
CONVENTIONAL PROGRAM 1 **Reflex[4] 12 oz/A + Prowl/Treflan** *incorporated 1 to 2"deep* *(prefer within 7 d of planting)*	**1. Warrant + Reflex** **2. Direx + Reflex** **3. Direx + Warrant** *Direx 10 to 20 oz/A;* *Reflex 8 to 10 oz/A;* *Warrant 32 to 40 oz/A*	**Roundup + Staple or Pyrimax[5]** *unless no Palmer up or ALS-resistant Palmer present; if so then apply:* **Roundup + Warrant** *no Palmer up*	**Roundup + Dual Magnum** *no Palmer up*	**Direx + MSMA[6]** *Palmer < 5"; add Envoke to improve morningglory control*
CONVENTIONAL PROGRAM 2 **Palmer free at planting with tillage or herbicides**	**1. Warrant + Reflex** **2. Direx + Reflex** **3. Direx + Warrant** *Direx 10 to 20 oz/A;* *Reflex 12 oz/A;* *Warrant 3 pt/A*			
CONSERVATION TILLAGE **Valor with Roundup or paraquat[2]** *Palmer < 1" & over 10 d before planting*	**1. Warrant + Reflex** **2. Direx + Reflex** **3. Direx + Warrant** *Direx 10 to 20 oz/A;* *Reflex 12 oz/A;* *Warrant 3 pt/A*			
Valor + Direx + paraquat[2] *Palmer 1-5" & over 10 d before planting*				
Direx + paraquat[2] *Palmer ≤ 5" & within 10 d of planting*				

[1]Follow all herbicide label use restrictions and plant back intervals.
[2]Add paraquat plus adjuvant at burndown and PRE if Palmer is emerged. If Direx (diuron) is applied burndown suggest avoiding PRE.
[3]Day interval assumes PRE residual herbicides were activated in timely fashion.
[4]The split Reflex program including preplant incorporated and PRE Reflex applications is the most effective program in cotton.
[5]Replace Staple/Pyrimax with Warrant if carryover or ALS-resistance is an issue.
[6]Add adjuvant. Suprend + MSMA is as effective as Direx + MSMA in controlling Palmer.

Glyphosate-Resistant Horseweed: Glyphosate-resistant horseweed (also called marestail) has been confirmed in most states surrounding Georgia and is expected to be present in Georgia. Horseweed primarily emerges in the fall and will often be in a rosette stage and large enough for identification in January or February. Pictures of small horseweed and identifying characteristics can be found at www.ppws.vt.edu/scott/weed_id/erica.htm.

It is critical that glyphosate-resistant horseweed be controlled before planting cotton; there are no good options to control this weed after emergence of Roundup Ready or conventional cotton varieties. Glyphosate-resistant horseweed can be controlled by tank mixes of Roundup plus 0.95 pound a.e. of 2,4-D (2 pt/A of 3.8 lb a.e./gal formulation) or Roundup plus 0.5 pt/A of Clarity. The tank mix with 2,4-D at this rate should be at least 30 days ahead of planting with at least 1"

of rainfall occurring between applications and planting. Cotton planting must be delayed at least 21 d after the accumulation of 1" of rainfall following Clarity application.

Horseweed that germinates in the fall can be controlled by winter burndown programs including 2,4-D or Clarity. However, plants that emerge late in the spring after burndown can become problematic. Valor will not assist in controlling emerged plants but will reduce problems with late-emerging horseweed. Weed scientists in Tennessee have found that Cotoran applied preemergence is probably the best option to control late-emerging horseweed. Gramoxone should be included with the Cotoran preemergence to kill emerged weeds.

Although somewhat less effective than a tank mix of glyphosate plus 2,4-D or Clarity, a mixture of Gramoxone plus Direx may adequately control horseweed if the mixture is applied when daytime temperatures exceed 75 F. Warm temperatures are critical for success with this treatment.

Liberty at 29 to 43 oz/A will also control horseweed if applied when daytime temperatures exceed 80 F. Liberty is an option to control spring-emerging horseweed at planting time or in situations where growers have failed to follow one of the programs previously outlined. Liberty can be applied anytime prior to cotton planting.

Hemp Sesbania: Hemp sesbania is very difficult to control with glyphosate after the first true leaf. When hemp sesbania is expected to be a problem, soil-applied herbicides such as Cotoran are in order. Follow with glyphosate plus Staple postemergence and a postemergence-directed application of a conventional herbicide combination. Combinations containing Cobra, Envoke, or Suprend would be a good option for the directed application. Envoke applied overtop of cotton would also be an option but the sesbania may be greater than 3" when the label allows Envoke to be applied topically to cotton.

Morningglory: One application of glyphosate usually will not adequately control morningglory larger than 3". It will, however, halt growth of small morningglory so that the weed can be taken out with cultivation or a second application of glyphosate. For morningglory (except the species tall morningglory) 3 inches or larger, a tank mix of glyphosate plus Staple is more effective than glyphosate alone. Envoke also is very effective on *Ipomoea* morningglory but should only be mixed with glyphosate and applied topically to Roundup Ready Flex cotton between the 7- and 12-leaf stages; sloppy directed applications are suggested for better weed coverage and less cotton injury. Cotoran applied preemergence could be used to aid in control.

At time of layby, conventional chemistries such as MSMA plus Caparol, Cobra, diuron, Layby Pro, Suprend, or Valor would be more effective than glyphosate. Diuron plus MSMA has become a standard layby mixture and even though it is more effective than glyphosate, the addition of Aim, Envoke, or ET with diuron plus MSMA is suggested for morningglory. If one chooses to use glyphosate, the addition of Aim, Caparol, diuron, Envoke, ET, Staple, Suprend, or Valor would be beneficial (see labels for application timings and cotton sizes).

Nutsedge: Two applications of glyphosate at the maximum use rate normally controls yellow and purple nutsedge. Good results also have been obtained with the full rate of glyphosate applied overtop followed by a directed application containing MSMA at 2.5 pints per acre or Envoke at 0.15 ounce per acre. In severely infested fields, best results will be obtained with two overtop applications of glyphosate at the full rate followed by a directed application mixture including MSMA, Envoke, or Suprend. Do not mix MSMA with glyphosate and apply overtop of cotton.

Roundup Ready corn (volunteer): Assure II, Fusilade DX, Select or Select Max may be applied alone or mixed with glyphosate to control Roundup Ready corn in Roundup Ready cotton. Suggested rates include the following: 5 or 8 oz/A of Assure II on corn up to 18 or 30", respectively; 6 oz/A of Fusilade DX on corn up to 24"; 4 to 6 oz/A of Select on corn up to 12 or 24", respectively; or 8, 10, or 12 oz/A of Select Max on corn up to 8, 18, or 24", respectively.

Roundup Ready soybean (volunteer): Cotoran preemergence may provide adequate control. Staple POST typically does not control soybean. However, Staple applied to three- to four-trifoliate soybean followed by a directed application of Caparol, diuron, or Suprend plus MSMA may provide adequate control. The most effective option is Envoke applied overtop to soybeans with less than six trifoliate leaves; control may be inadequate once soybean reaches 12".

Tropical Spiderwort: Prior to Palmer amaranth challenging cotton growers, spiderwort was the most problematic weed of cotton. However, current programs implemented to control Palmer amaranth have indirectly controlled spiderwort (Table 5). Dual Magnum and Warrant offer the greatest level of residual control in cotton. Gramoxone, glyphosate + Aim, glyphosate + Staple, Direx + MSMA and glyphosate + 2,4-D offer the greatest opportunity to control emerged plants.

Table 5. Managing Tropical Spiderwort in Roundup Ready Cotton. [1]

Preemergence	POST 1	POST 2	Layby Directed
Warrant[2] + *herbicides appropriate for other weeds*	**Roundup + Staple, Dual Magnum[3] or Warrant[2]** *(Use Staple if spiderwort or Palmer amaranth are up)*	**Roundup + Dual Magnum[3]**	**Direx + MSMA** *(Add Aim if spiderwort is greater than 3 inches; the addition of Dual Magnum[3] or Warrant[2] would improve residual control)*

[1] Deep turning the land will provide fair control of spiderwort.
[2] Apply Warrant no more than twice per season.
[3] Dual Magnum can be applied topically once per crop.

Weed Management in GlyTol LibertyLink Cotton

Varieties are available under both Stoneville and Fibermax brands that contain both the GlyTol and the LibertyLink traits. The GlyTol trait provides for excellent tolerance to glyphosate and the LibertyLink trait provides for excellent tolerance to glufosinate (Liberty herbicide).

Any brand of glyphosate herbicide registered for use overtop of cotton may be used in cotton containing the GlyTol trait, unless expressly prohibited by the herbicide label. Application rates, timing of application and maximum use rates per season are the same as for Roundup Ready Flex cotton. The Liberty label currently allows three applications of 29 oz/A, for a season total of 87 oz/A. Alternatively, one can apply 30 to 43 oz/A once followed by an application of 29 oz/A, for a season total of a maximum of 72 fluid ounces. Labels allow Liberty application from cotton emergence until the early bloom stage.

Weed Management in Widestrike Cultivars

LibertyLink cotton was transformed to include the bacterial *bar* gene which codes for an enzyme that effectively deactivates glufosinate (Liberty herbicide). LibertyLink tolerance to Liberty is excellent. In Phytogen's Widestrike cotton, the bacterial *pat* gene was inserted for use as a selectable marker during transformation events for lepidopteran pest resistance. The *pat* gene also codes for the enzyme that deactivates glufosinate. However, tolerance of varieties with the Widestrike trait to Liberty is not complete and some injury is expected with topical Liberty applications. Injury is most often leaf burn and chlorosis with occasional stunting and leaf drop, and can range from minor to rather significant.

According to a recent EPA interpretation, Liberty herbicide can be applied to WideStrike cotton. *However, the grower is liable for any crop injury resulting from the application. Neither Bayer CropScience, Dow AgroSciences/PhytoGen nor the University of Georgia recommend or warrant the use of Liberty on WideStrike cotton.*

Research throughout the Southeast has not shown significant yield reduction of WideStrike cotton from two Liberty applications at 29 fluid ounces applied to 1- to 2-leaf cotton and again to 5- to 7-leaf cotton. Rates in excess of 29 fluid ounces are discouraged on Widestrike cotton; higher rates cause more burn with possible stunting and leaf drop. The addition of ammonium sulfate and other herbicides is also discouraged. Additionally, application of Liberty after the eight-leaf stage of WideStrike cotton should be avoided. Application near first bloom or later may cause unacceptable crop injury, leaf drop, and yield reduction.

Weed Management in Cotton Using Liberty-Based Weed Management Programs

Protecting Liberty

Because of weed resistance to glyphosate and because herbicides with new modes are action are not being developed, Liberty will play a significant role in cotton weed management for the foreseeable future. It is imperative that growers follow sound resistant management strategies to avoid or delay selection for resistance to Liberty. In addition to diversifying and integrating other herbicides and cultural practices into a management program, growers are strongly encouraged to maximize Liberty application procedures while making no more than two applications per year.

PROTECTING LIBERTY FOR FUTURE SUSTAINABILITY: THE DECISION IS YOURS!

1. **Do not make more than 2 applications of Liberty per year.**
2. **Spray Liberty when the biggest pigweed in the field is 3 inches or smaller.**
3. **Never ever use a reduced rate!**
4. **Avoid applications within 1.5 hr of sunrise and 1 hr of sunset.**
5. **Apply at 15 GPA using a speed, spray tip, and pressure that delivers a medium spray droplet.**
6. **Integrate herbicide programs with 1) hand weeding, 2) tillage, and/or 3) heavy rye cover crop residue.**

Liberty Needs Timely Applications

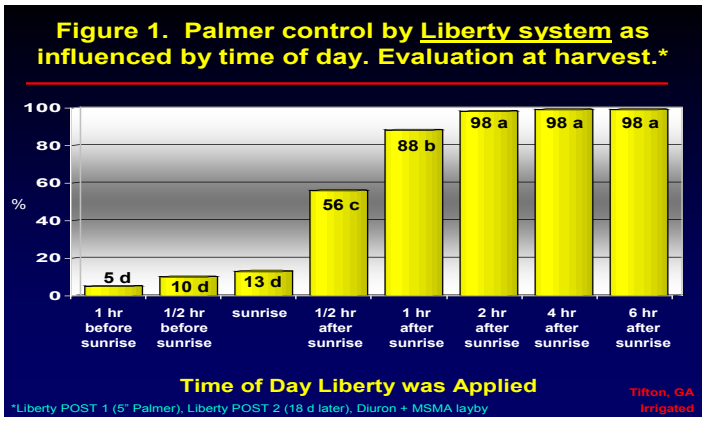
The optimum weed size for treatment with Liberty varies, depending on the weed species and growing conditions. Pigweeds, tropic croton, spurred anoda, velvetleaf, Florida beggarweed, eclipta, groundcherry, spotted spurge, common purslane, and annual grasses should be no more than 3 inches tall (tallest plant in the field should be 3 inches or less). Goosegrass should be 2 inches or less. Under dry or other stressful conditions, Palmer amaranth and all annual grasses should be 2 inches or smaller when treated. Under dry conditions, applications should be made prior to plant stress causing leaf or stem rolling.

Application Equipment Generating the Ideal Droplet Size

Liberty behaves much like a contact herbicide, so good spray coverage is necessary. The label recommends flat-fan nozzles, at least 40 pounds pressure per square inch (psi) and a minimum of 10 gallons per acre spray volume. Ideally, the spray volume is at least 15 gallons per acre. Ultimately the goal with Liberty is to achieve a medium spray droplet; thus, growers must understand the relationship of speed, pressure, and nozzle type to achieve this goal.

Time of Day When Liberty is Applied Impacts Weed Control

Efforts have been aggressive since 2011 to understand how time of day impacts the activity of Liberty on Palmer amaranth. Results show that time of day can have a tremendous influence on activity by Liberty (Figure 1 below). Therefore **Liberty should not be applied within 1.5 hours of sunrise and 1 hour of sunset.**



Planting into a Seedbed Free of Palmer amaranth

The single greatest challenge for growing cotton is making sure emerged Palmer amaranth plants are not present when planting. Numerous options to prevent this issue are available and include both tillage and herbicides. For conservation tillage, the use of Valor and/or Direx is critical. Valor is the most effective residual herbicide while Direx plus paraquat (Gramoxone, others) offers the most effective control of emerged plants (Table 6). Follow the appropriate plant back restrictions with these herbicides as noted in Table 7. For conventional tillage production, tillage alone can be effective but the single most effective program would be a preplant incorporated application of Reflex plus either Treflan or Prowl (Table 6).

Table 6. The most effective option to eliminate emerged Palmer amaranth at planting.

Prior to Planting	
CONVENTIONAL TILLAGE **Option 1** **Reflex 12 oz/A + Prowl/Treflan** *preplant incorporate 1 to 2 inches deep* *(preferably within 7 days of planting)* **Option 2** **Keep clean with tillage or herbicides**	**CONSERVATION TILLAGE** **Option 1** **Valor + glyphosate or paraquat** *(Palmer < 1" and more than 10 d before planting)* **Option 2** **Valor + Direx + paraquat** *(Palmer 1 to 5" and more than 10 d before planting)* **Option 3** **Direx + paraquat** *(Palmer ≤ 5" and less than 10 d before planting)*

Table 7. Plant back intervals for Valor or Direx applied at burndown.

Herbicide Choice	Time Interval Before Planting	Special Comments
Valor	strip-till after applying Valor but before planting: ≥10 d no-till with <30% residue: 28 d and 1 inch rain no-till with >30% residue: 21 d and 1 inch of rain	Do not exceed 2 oz/A if planting within 30 days. ***If applying Reflex (or generic) PRE, add an additional 7 days to the no-till planting intervals.***
Direx	no till: 7 d strip till after application and before planting: 0 d	Do not exceed 1 qt/A, see label for rate on your soil. Do not use PRE if used preplant within 10 days of planting.

Selecting the Ideal Preemergence (PRE) Herbicide for a GlyTol LibertyLink System

Residual at-plant herbicides are required to grow any cotton cultivar in Georgia. Without question, Reflex is the most effective Palmer amaranth herbicide available at planting but this herbicide is not required in fields where timely Liberty applications are made. In severely infested fields, one should still consider using Reflex in mixture with Warrant or Direx while other fields could be treated with a Reflex mixture or Warrant + Direx (Table 8). When comparing Warrant vs Direx as a tank mix partner for Reflex one should consider: 1) Warrant offers a greater level of residual Palmer control and will sit on the soil longer waiting on activation; 2) Warrant should be used for fields infested with tropical spiderwort as Liberty is not very effective; and 3) Direx offers the ability to control emerged weeds, especially Palmer amaranth. Paraquat plus adjuvant should always be included with the PRE if any Palmer is emerged.

Table 8. Effective preemergence options for a Liberty-based system.

Preemergence Option	Comments
1. Warrant + Reflex 2. Direx + Reflex 3. Warrant + Direx	1. Cotoran can be used to effectively replace Direx in fields with minimal Palmer infestations or for improved control of other broadleaf weeds. 2. Use 12 oz/A of Reflex for most soil types except when using the split reflex program where 8 to 10 oz/A PRE following 12 oz/A PPI is in order. 3. Warrant use rate is typically 48 oz/A unless planting into very light soils where 32 to 40 oz/A would be in order. 4. Direx use rate is typically between 10 and 20 oz/A with lower rates on lighter soils and in conditions where heavy rainfall/irrigation is expected.

Tank Mixes With Liberty Applied Overtop of GlyTol/Liberty Link Cotton

Staple LX can be mixed with Liberty applied overtop from the cotyledonary stage until 60 days before harvest. The typical rate of Staple LX would be 1.9 fluid ounces per acre to improve control of emerged sensitive species and to provide residual control or suppression of sensitive species such as pigweeds. The Staple LX rate can be increased to 2.6 fluid ounces per acre to improve control of troublesome weeds. Staple will not control biotypes of palmer amaranth resistant to ALS herbicides. *Injury from Liberty plus Staple mixtures is often greater than injury with Roundup plus Staple mixtures.*

Dual Magnum can be tank mixed with Liberty applied overtop to emerged cotton until 100 days prior to harvest. Dual Magnum will not improve control of emerged weeds. If activation is timely, it will provide residual control of annual grasses, pigweeds and tropical spiderwort. Expect some

minor speckling/necrosis with occasional moderate speckling/necrosis; cotton will recover quickly. Do not tank mix both Dual Magnum (or generic metolachlor) and Staple LX (or generic) with Liberty and try to avoid applications when heavy dew is present on the cotton!

Roundup can be mixed with Liberty and applied over GlyTol LibertyLink cotton. Tank mixes of these herbicides have shown to be antagonistic (reduced control), especially when the rate of one or both of the herbicides is reduced. Generally speaking, glyphosate does not impact the activity of glufosinate, but glufosinate can antagonize glyphosate. Research the suggest the primary concern is for grass species where glyphosate is less effective in mixture than when applied alone.

Warrant may be mixed with Liberty applied overtop to emerged cotton through the seven leaf stage of cotton development. Applications after this period pose significant injury potential. Even with timely applications expect some minor speckling/necrosis with occasional moderate speckling/necrosis; cotton will recover quickly. Do not tank mix both Warrant and Staple LX (or generic) with Liberty and try to avoid applications when heavy dew is present on the cotton! If activation is timely, Warrant will provide residual control of annual grasses, pigweeds and tropical spiderwort.

POST Graminicides should not be mixed with Liberty because of reduced grass control.

Layby Applications for GlyTol/Liberty Link Systems

In nearly all grower fields, Palmer amaranth is the dominate species present thus applications of Direx (diuron) + MSMA or Suprend + MSMA is in order as these options are more effective than Liberty or glyphosate mixtures. In fact, only Gramoxone + Direx (under hoods) is as effective as Direx + MSMA in controlling emerged Palmer amaranth. One common weakness of Direx + MSMA, however, is the lack of control of morningglory larger than three inches. When Palmer amaranth and morningglory need to be controlled one should mix either 1) Aim, 2) Envoke, or ET with Direx plus MSMA; make certain cotton is large enough to tolerate an Aim or ET application.

If Palmer amaranth is not problematic but grasses are the predominant problem and they are larger than one inch, glyphosate will be the more effective option. If one decides to use glyphosate or Liberty, tank mix partners are required to improve weed control and assist in resistance management.

Difficult-to-Control Weeds with Liberty in a GlyTol/Liberty Link Systems

Dayflower. Liberty will not control spreading dayflower. Cotoran plus Warrant at planting would be suggested. Once emerged but less than 3 inches, spreading dayflower can be controlled with Staple LX applied postemergence at 2.6 fluid ounces per acre or directed herbicide combinations containing MSMA. Glyphosate is the more effective than Liberty.

Doveweed. Liberty has minimal activity on doveweed with regrowth likely. Gramoxone, applied under a hood, is very effective on doveweed. Additionally, preliminary results indicate that Dual Magnum and Warrant if activated before germination and Valor plus MSMA directed to emerged doveweed can be effective. Glyphosate is the more effective than Liberty.

Goosegrass and other annual grasses. In general, Liberty is more effective on broadleaf weeds than grasses. Timing of application to grasses, and especially goosegrass, is critical. Two applications are normally needed to control goosegrass. Alternatively in cotton tolerant to both glyphosate and Liberty, the use of an effective at plant residual herbicide followed by glyphosate

prior to goosegrass reaching 3" in height is in order. A soil-applied herbicide Prowl, Cotoran or Warrant preemergence can help tremendously in controlling goosegrass and other annual grasses. Postemergence mixtures including Dual Magnum or Warrant will also provide residual control of later emerging plants. Goosegrass often emerges later in the season.

Liberty should not be tank mixed with postemergence grass-control herbicides. These tank mixes are very antagonistic (reduced grass control).

Florida pusley. Liberty has minimal activity on Florida pusley and successful management will depend on the use of effective soil-applied herbicides such as Prowl or Treflan incorporated or Prowl, Cotoran or Warrant preemergence. Glyphosate is the more effective than Liberty; thus, the use of an effective at plant residual herbicide followed by glyphosate prior to pusley reaching 1" in height is in order.

Nutsedge. Liberty burns nutsedge but the weed usually grows back. A far more effective solution is making sequential applications of glyphosate followed by a conventional layby including MSMA. In GlyTol Liberty Link cotton only, a glyphosate plus Liberty mixture could be used as one of the glyphosate applications.

Palmer amaranth. Palmer amaranth can be consistently controlled by Liberty as long as the application is made when the largest pigweed in the field is 3 inches tall. A systems approach using residual herbicides at burndown, at planting, and postemergence is required. In GlyTol LibertyLink cotton, one or two applications of Liberty may be needed (Table 9, just below).

Table 9. Managing Palmer amaranth with ONE or TWO applications of Liberty in GlyTol Liberty Link Cotton.[1]

Preplant	Preemergence (PRE)[2]	POST 1 ~17 d after PRE[3]	POST 2 ~ 15 d after POST 1[3]	Layby ~18 d after POST 2[3]
Tillage OR one of the following:		ONE LIBERTY APPLICATION[4]		
Valor + glyphosate or paraquat[2] *Palmer < 1" and over 10 d before planting*	**1. Reflex + Warrant 2. Warrant + Reflex 3. Direx + Warrant** *Direx 10-20 oz/A: Reflex: 10-12 oz/A; Warrant: 40-48 oz/A*	**Liberty + Dual Magnum or Warrant** *(Palmer ≤ 3")*	**Roundup + Staple or Dual Magnum** *(Palmer < 1" with Staple[5]; no Palmer up for Dual)*	**Direx + MSMA[6]** *Palmer ≤ 5"; add Envoke to improve morningglory control*
Valor + Direx + paraquat[2] *Palmer 1-5" and over 10 d before planting*				
Direx + paraquat[2] *Palmer ≤ 5" and within 10 d of planting*		**Liberty + Warrant** *(Palmer ≤ 3")*	**Liberty + Dual Magnum** *(Palmer ≤ 3")*	
		TWO LIBERTY APPLICATIONS		

[1]Cotton must be tolerant to Liberty (glufosinate) herbicide. Follow all labeled herbicide use restrictions, including application rates and plant back intervals.
[2]Add paraquat plus adjuvant with burndown and PRE if Palmer is emerged. If Direx (diuron) is applied burndown suggest avoid using it again PRE.
[3] Day interval assumes PRE residual herbicides were activated in a timely fashion; the key to this system is to apply Liberty prior to Palmer reaching 3".
[4] If Palmer is not up at POST 1 but grasses are intense then switch the order of the Roundup and Liberty mixtures using Roundup mixtures at POST 1.
[5] Staple will not control ALS-resistant weeds.
[6] Add adjuvant. Suprend + MSMA is as effective as diuron + MSMA on Palmer.

Tropical Spiderwort. Liberty is not effective on tropical spiderwort and a systems approach will be required to manage the pest in GlyTol LibertyLink cotton (Table 10).

Table 10. Managing Tropical Spiderwort in GlyTol LibertyLink Cotton. [1]

<table>
<tr><th>Preemergence</th><th>POST 1</th><th>POST 2</th><th>Layby Directed</th></tr>
<tr><td rowspan="2">Warrant[2] + herbicides appropriate for other weeds</td><td>Liberty + Staple, Dual Magnum or Warrant
OR
Roundup + Staple, Dual Magnum or Warrant</td><td>Liberty + Staple, Dual Magnum or Warrant
OR
Roundup + Staple, Dual Magnum or Warrant</td><td rowspan="2">Direx + MSMA
Add Aim if spiderwort is greater than 3 inches; the addition of Dual Magnum or Warrant would improve residual control</td></tr>
<tr><td colspan="2"><u>Considerations for selecting POST 1 and 2 treatments:</u>
1. Use Liberty mixtures if Palmer amaranth has emerged and use Roundup mixtures if Palmer has not emerged.
2. With Liberty or Roundup: add Staple if spiderwort has emerged but use Dual or Warrant if spiderwort has not emerged.</td></tr>
</table>

[1] Deep turning the land will provide fair control of spiderwort.

Postemergence-Overtop Herbicides - Any Variety

Envoke can be applied overtop of cotton with a minimum of five (prefer 7) leaves up to 60 days prior to harvest. Directed application is encouraged to avoid injury and to ensure better spray coverage on weeds below the crop canopy. Envoke controls or suppresses nutsedge plus a number of broadleaf weeds that are less than 4 inches in height. Note that Envoke does not control smallflower morningglory, jimsonweed, prickly sida, spreading dayflower, or tropical spiderwort, and it is not very effective on tropic croton or Palmer amaranth.

Envoke and Staple have the same mode of action. Hence, Palmer amaranth resistant to Staple will not be controlled by Envoke. Palmer amaranth resistant to these herbicides is common.

Cotton will sometimes be injured by Envoke applied overtop. Injury is expressed as yellowing in the growing point and shortened internodes. Some degree of crop response can almost always be expected. In many cases, injury is relatively minor and the crop recovers without an adverse effect on yield or quality. On occasion, however, moderate to severe injury has been observed. Growers are encouraged to not apply Envoke to cotton with less than seven leaves and to not apply the herbicide to cotton under stress from wet or dry weather or thrips. Also, carefully follow label directions for adjuvant usage, and do not tank mix Envoke with other herbicides (other than Staple, see label) when applying overtop cotton. Tank mix Envoke with only those insecticides specifically mentioned on the Envoke label. Tank mixes of Envoke and mepiquat chloride are strongly discouraged.

Tank mixes of Envoke with Assure II, Fusilade DX, Poast, Poast Plus, Select or Select Max should be avoided. Separate applications of Envoke and the grass-control herbicides by at least 3 days if the grass-control herbicide is applied first or 5 days if Envoke is applied first.

Staple LX or Pyrimax can be applied overtop of cotton from the cotyledonary stage until 60 days before harvest. Two applications per year are allowed but do not 5.1 oz/A total.

If applied in a timely manner, these herbicides control many broadleaf weeds with notable exceptions including the following: lambsquarters, ragweed, sicklepod, spurge, tall morningglory, or tropic croton. Most susceptible broadleaf weeds should not be taller than 3 inches. Prickly sida must be 1 inch or less for acceptable control. Palmer amaranth should be 2 inches or less. Palmer amaranth resistance to ALS-chemistry is common across GA.

Do not mix with Assure II, Fusilade DX, Poast, Poast Plus, Select or Select Max because antagonism (reduced grass control) is often observed. When making sequential applications with postemergence grass-control herbicide, apply the Staple/Pyrimax at least 5 days before or 3 days after application of the grass-control herbicide.

Grass-control herbicides. Assure II, Fusilade DX, Poast, Poast Plus, Select, and Select Max can be applied overtop of cotton from emergence through mid-season without injury concerns. These products control annual and perennial grasses but are ineffective on nutsedge and broadleaf weeds. Poast, Poast Plus, Select, and Select Max tend to be the more effective options over a range of annual grass species and environmental conditions. Tank-mixing broadleaf herbicides, such as Staple or Envoke, with these postemergence grass-control herbicides is not recommended.

Postemergence-Directed Herbicides - Any Variety

A number of herbicide combinations are available for directed application to any variety of cotton and include the following: Caparol plus MSMA, Cobra plus MSMA, Cobra plus Direx plus MSMA, Cotoran plus MSMA, Direx plus MSMA, Layby Pro plus MSMA, Linex plus MSMA, Suprend plus MSMA, and Valor SX plus MSMA. Dual Magnum, warrant, Aim, and ET may be mixed with some of these combinations. Staple or Envoke could be used at layby as well.

The postemergence-directed herbicides listed above are primarily for annual broadleaf weeds and nutsedge. MSMA in these mixtures will control annual grasses less than 1.0 inch. Except for Aim, ET, MSMA, and Cobra plus MSMA, the options listed above will also provide some residual control of sensitive weeds.

Perennial Broadleaf Weeds

Perennial broadleaf weeds, such as horsenettle, trumpetcreeper, common milkweed, and hemp dogbane, are primarily a problem in conservation tillage. Soil-applied herbicides will not control perennial broadleaf weeds, and, with the exception of horsenettle, conventional postemergence-directed herbicides are ineffective. Acceptable control of horsenettle has been obtained with postemergence-directed herbicide combinations containing MSMA. Two applications of MSMA or combinations containing MSMA are usually needed. Harvest-time applications of glyphosate are also an option to suppress perennial weeds for the following year (see preharvest section).

Perennial broadleaf weeds can be suppressed or controlled with multiple applications of glyphosate applied to Roundup Ready cotton. Later applications are generally more effective on perennials, and two applications are more effective than one. Adequate spray coverage should be obtained on low-growing perennials such as trumpetcreeper and horsenettle with standard directed sprayers.

Curly dock is best controlled by a preplant application of Harmony Extra.

Perennial broadleaf weeds can be suppressed or controlled in corn grown in rotation with cotton. In corn, an early postemergence application of dicamba alone or mixed with a nicosulfuron-containing herbicide followed by a lay-by application of dicamba is most effective. Alternatively, glyphosate or a tank mix of 2,4-D plus dicamba can be applied to infested spots after corn harvest.

Preharvest Herbicide Application

Preharvest herbicide applications are of questionable value in most cases. Desiccating mature weeds likely will not increase harvesting efficiency nor reduce harvesting losses. The major exception would be fields heavily infested with viney weeds such as morningglory and cowpea. Problems with extraneous green matter in harvested cotton are probably overstated. Lint staining from weeds has not been voiced as a significant problem in spindle-picked cotton. Desiccating weeds will more likely increase rather than decrease trash in cotton because gins can remove green plant parts more easily than finely ground, desiccated plant parts. However, if present in large quantities, extraneous green matter can increase the potential for overheating, rot, and stain if the cotton is packed into a module and the module is not properly monitored.

There are no established guidelines for determining when the level of weed infestation justifies a preharvest herbicide application. The information below is based on general observations.

Annual Weeds

Aim or ET. These herbicides are also registered for use as defoliants. Good desiccation of morningglory and cocklebur have been observed with excellent spray coverage. Results on pigweed species have been inconsistent but generally not acceptable. These products will not desiccate grasses or sicklepod. See labels regarding use of adjuvants.

Glyphosate. Glyphosate can be applied in Roundup Ready Flex varieties seven or more days ahead of harvest regardless of the percentage of open bolls. Glyphosate-defoliant combinations generally have been effective on annual grasses, common ragweed, lambsquarters, pigweed (not resistant), cocklebur, tropic croton, cowpea, and sicklepod.

Gramoxone. Either add 2 to 6 oz of product with standard defoliants or apply after cotton defoliation. When applying after cotton defoliation and at least 80 percent of the bolls are open, the remaining bolls expected to be harvested are mature, and most of the cotton leaves have dropped, apply 16 to 32 oz/A of Gramoxone 2 SL. Broadcast the Gramoxone in a minimum of 20 gallons of water per acre and add 1 pint of nonionic surfactant per 100 gallons of water. Initiate harvest as soon as leaves are toughened (the "green" is removed) but before foliage becomes brittle. Gramoxone will desiccate most annual weeds with Florida pusley being an exception. Cotton must be harvested in a timely manner bark and cotton plant death can occur rapidly.

Perennial Weeds

Glyphosate can be applied in the fall to control or suppress perennial weeds for the following year. Ideally, glyphosate should be applied after defoliation for improved coverage and this will allow application only for infested areas. Maximum labeled use rates are suggested for nutsedge, trumpetcreeper, common milkweed, bermudagrass, horsenettle and hemp dogbane.

Glyphosate should be applied at least 10 days before the first killing frost.

COTTON WEED CONTROL

WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
EARLY PREPLANT BURNDOWN				
Emerged annual weeds but does not adequately control primrose, geranium, large radish, glyphosate- resistant horseweed or pigweed.	glyphosate 4.0 SL (3 lb a.e.) 5.4 SL (4 lb a.e.) 5.0 SL (4.17 lb a.e.) 5.5 SL (4.5 lb a.e.) 6.0 SL (5.0 lb a.e.) MOA 9	 32 to 48 fl oz 24 to 36 fl oz 23 to 34 fl oz 22 to 32 fl oz 19 to 29 fl oz	0.75 to 1.13 (lb a.e.)	Apply anytime prior to planting to control emerged weeds. Control of grain cover crops: Wheat < 12": 0.56 lb a.e. Wheat > 12": 0.75 lb a.e. Rye < 12": 0.56 lb a.e. Rye > 12" (no seed head): 0.75 lb a.e. Rye with seed head: 0.56 lb a.e.
Emerged primrose, wild radish, and spiderwort.	2,4-D amine 4 L 4.7 L 5 L MOA 4	 12 to 24 fl oz 10 to 20 fl oz 9 to 18 fl oz	0.38 to 0.75	The MOST CONSISTENT and effective burndown program for winter weeds is a 2,4-D application in Feb. when weeds are small and herbicide coverage is adequate followed by glyphosate or paraquat mixtures at or near planting. See product used for cotton plant back interval. PRIMROSE: Apply 0.18 to 0.24 lb ae/A RADISH: Apply 0.5 to 0.75 lb ae/A HORSEWEED: Apply 0.75+ lb ae/A
Emerged weeds including primrose, radish, tropical spiderwort, and most other weeds. 2,4-D rates are low to control resistant horseweed or pigweed.	glyphosate + 2 ,4-D amine 4 L 4.7 L 5 L MOA 9 + 4	see glyphosate + 8 to 16 fl oz 6 to 12 fl oz 6 to 11 fl oz	0.38 to 1.13 + 0.24 to 0.48	See comments for glyphosate applied alone. Most, but not all, brands of 2,4-D may be applied at least 30 days ahead of cotton planting. 2,4-D is the most effective option available for burndown of cutleaf eveningprimrose and 0.24 to 0.38 lb ae/A will control primrose. Glyphosate plus 2,4-D may not adequately control Carolina geranium. Use amine formulations of 2,4-D.
Aim improves control of emerged morningglory, tropical spiderwort, and very small ≤ 1" glyphosate-resistant Palmer amaranth.	glyphosate + carfentrazone (Aim) 2 EC MOA 9 + 14	see glyphosate + 0.5 to 1.0 fl oz	0.75 to 1.13 + 0.008 to 0.016	See comments for glyphosate applied alone. May be applied as a burndown treatment anytime prior to planting. Aim does not provide residual weed control.
Dicamba improves primrose, morningglory, and glyphosate-resistant horseweed or pigweed control. Suppresses geranium and curly dock.	glyphosate + dicamba (Clarity) 4 SL MOA 9 + 4	see glyphosate + 8 fl oz	0.75 to 1.13 + 0.25	See comments for glyphosate applied alone. Following application of dicamba AND a minimum of 1 in. of rainfall, a waiting period of at least 21 days is required before planting. Dicamba can be applied alone with little to no effect on the small grain cover. Dicamba is less effective than 2,4-D on primrose but more effective on horseweed.
Diuron improves control of emerged Palmer amaranth and provides about 10 days of residual if it reaches the ground and is activated. The addition of 2,4-D or Valor may improve weed control; follow plant back intervals for these products if included.	glyphosate + diuron (Direx 4 L)	see glyphosate + 1 to 1.5 pt	0.75 to 1.13 + 0.5 to 0.75	A state label allows Direx to be applied up to the day ahead of planting if strip tillage implement is run between application and planting. If no tillage occurs between application and planting then one should wait at least 10 days prior to planting. This label ends Dec. 31 of each year, confirm the label has not expired prior to following these guidelines. Do not apply on sand or loamy sand soils. If following shortened plant back interval, suggest avoiding diuron PRE.

WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
EARLY PREPLANT BURNDOWN (continued)				
Valor improves emerged primrose and radish control. Valor at 2 oz/A provides residual control of pigweed, pusley, smallflower morningglory and other sensitive weeds for up to 6-8 wk if it reaches the soil and is activated. *Valor and/or diuron should be applied preplant to every reduced till acre of cotton.*	glyphosate + flumioxazin (Valor SX) 51 WDG MOA 9 + 14	see glyphosate + 2 oz	0.75 to 1.13 + 0.063	<u>In strip-till cotton</u>: Valor can be applied 10 d ahead of planting as long as the strip till operation occurs between applying Valor and planting. <u>In no-tillage</u> production or when the strip is implemented prior to application. Valor plantback interval should be as follows: 1. < 30% ground cover wait 28 days PLUS 1 inch of rain 2. > 30% ground cover wait 21 days PLUS 1 inch of rain. **IF REFLEX (or generic) will be applied PRE in no-tillage systems; suggest adding 7 additional days to the plant back interval**. Valor is less effective than 2,4-D on emerged primrose; the addition of 2,4-D at 0.24 lb ae/A will control primrose and most other weeds. Add a surfactant or crop oil (preferred), regardless of glyphosate brand. *For PPO-resistance management, make only two applications of Reflex (generic) or Valor in two years. CAREFULLY follow label directions for cleaning out the sprayer <u>after each days use!</u>*
ET improves control of emerged morningglory and small < 1" glyphosate- resistant Palmer amaranth.	glyphosate + pyraflufen ethyl (ET) 0.208 EC MOA 9 + 14	see glyphosate + 0.5 to 2.0 fl oz	0.75 to 1.13 + 0.0008 to 0.003	May be applied as a burndown treatment anytime prior to planting. ET does not provide residual weed control.
Improved control of of henbit, chickweed, Carolina geranium, and wild radish compared to glyphosate alone. Use Harmony Extra or Nimble to improve control of curly dock. 2,4-D is more effective on primrose. Dicamba and 2,4-D are more effective on horseweed. Valor and diuron are more effective on pigweed.	glyphosate + thifensulfuron + tribenuron (FirstShot SG) 50 SG MOA 9 + 2 + 2	see glyphosate + 0.5 to 0.8 oz	0.75 to 1.13 + 0.008 to 0.013 + 0.008 to 0.013	Apply at least 14 days prior to planting. Include nonionic surfactant at 1 to 2 qt per 100 gal spray or crop oil concentrate at 1 to 2 gal per 100 gal spray.
	glyphosate + thifensulfuron + tribenuron (Harmony Extra SG with TotalSol) 50 SG (Harmony Extra, Nimble) 75 WDG MOA 9 + 2 + 2	see glyphosate + 0.75 oz 0.5 oz	0.75 to 1.13 + 0.0156 + 0.0078	

[1]Mode of Action (MOA) code can be used to delay weed resistance by increasing herbicide diversity in a management program.

WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
EARLY PREPLANT BURNDOWN (continued)				
Emerged annual weeds. Does not control immature eveningprimrose, large horseweed, curly dock, swinecress, immature radish, or large grasses.	paraquat (Gramoxone SL) 2 SL (Firestorm, Parazone) 3SL MOA 22	 2.5 to 4.0 pt 1.7 to 2.7 pt	0.63 to 1.0	Apply any time prior to planting to control emerged weeds. Add nonionic surfactant at 2 pt per 100 gal of spray mix or crop oil concentrate at 1 gal per 100 gal spray mix. **The addition of diuron is strongly encouraged.** Apply 0.63 lb ai for wheat and 0.5 lb ai for rye cover crop. Cover crops must be mature (seedheads present) for adequate control.
Emerged annual weeds and provides residual control if diuron reaches the soil and is activated. Effective on <u>mature</u> primrose and wild radish. **<u>By FAR</u>** <u>the most effective option for emerged glyphosate-resistant pigweed.</u> *Diuron and/or Valor should be applied on every reduced tillage cotton acre.*	paraquat (Gramoxone 2 SL) 2SL (Firestorm, Parazone) 3SL + diuron (Direx) 4 F MOA 22 + 7	 2.5 to 4.0 pt 1.7 to 2.7 pt + 1.5 to 2.0 pt	0.63 to 1.0 + 0.75 to 1.0	See comments for paraquat alone. A Georgia 24 © label for Georgia allows Direx (only Direx) to be applied up to the day ahead of planting if a strip tillage implement is run between Direx application and planting. If no tillage occurs between Direx application and planting then one should wait at least 10 days prior to planting. This label ends Dec.31 of each year, confirm the label has not expired before following these guidelines. If following shortened plantback interval, suggest avoiding diuron PRE. **Add crop oil concentrate at 1 gal per 100 gal spray mix.** When mixed with crop oil concentrate and applied in May when winter weeds are mature, control is much greater than when applied on immature winter weeds.
Paraquat mixtures with diuron are more effective on emerged Palmer amaranth; however, Valor is more effective in providing residual Palmer amaranth control. *Diuron and/or Valor should be applied on every reduced tillage cotton acre.*	paraquat (Gramoxone 2 SL) 2SL (Firestorm, Parazone) 3SL + flumioxazin (Valor SX) 51 WDG MOA 22 + 14	 2.5 to 4.0 pt 1.7 to 2.7 pt + 2 oz	0.63 to 1.0 + 0.063	Follow preplant intervals noted for Valor above. Include crop oil with mixture. When spraying immediately after rolling rye with seedheads; paraquat (3 SL) rate can be reduced to 10 oz/A; as long as no other weed is present. Contact your local Extension Office for the latest circular on this system. *FOR PPO-resistance management, make only 2 applications of Valor or Reflex (generic) in 2 years. CAREFULLY follow label directions for cleaning out sprayer after each day's use.*
Winter annual broadleaf weeds such as henbit, chickweed, small wild radish, and curly dock. DO NOT anticipate control for Palmer amaranth.	rimsulfuron + thifensulfuron (LeadOff) 33 SG	 1.5 oz	0.0156 + 0.0156	Apply at least 30 days prior to planting. Can increase rate to 2 oz/A if applying at least 60 days prior to planting. Also suggest at least 1 inch of rain accumulation prior to planting. Mixing 2,4-D with LeadOff will improve control of problematic weeds such as radish, primrose, and horseweed.

[1]Mode of Action (MOA) code can be used to delay weed resistance by increasing herbicide diversity in a management program.

WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
EARLY PREPLANT BURNDOWN OF GLYPHOSATE-RESISTANT HORSEWEED				
Glyphosate-resistant horseweed.	glyphosate + 2 ,4-D amine + flumioxazin (Valor SX) 51 WDG MOA 9 + 4 + 14	see glyphosate + see label + 2 oz	0.75 to 1.13 + 0.75 to 1.0 + 0.063	Glyphosate-resistant horseweed is likely present in GA. Glyphosate plus 2,4-D plus Valor SX or glyphosate plus dicamba plus Valor are the **preferred treatments.** See previous comments concerning waiting intervals after applying each product. The 2,4-D or dicamba is needed in the mixture to control emerged resistant horseweed while the Valor provides residual control that may germinate after the application. **For PPO-resistance management, make only two applications of Valor or Reflex in two years.**
	glyphosate + dicamba (Clarity) 4 SL + flumioxazin (Valor SX) 51 WDG MOA 9 + 4 + 14	see glyphosate + 8 fl oz + 2 oz	0.75 to 1.13 + 0.25 + 0.063	Carefully follow label directions for cleaning out the sprayer after each day's use.
	paraquat (Gramoxone Inteon) 2SL (Firestorm, Parazone) 3SL + diuron (Direx) 4 F MOA 22 + 7	4.0 pt 2.7 pt + 1.5 to 2.0 pt	1.0 + 0.75 to 1.0	A Georgia 24 © label allows Direx (only Direx) to be applied up to the day ahead of planting if a strip tillage implement is run between Direx application and planting. If no tillage occurs between Direx application and planting then one should wait at least 10 days prior to planting. This label ends Dec.31 of each year, confirm the label has not expired before following these guidelines. If following shortened plantback interval, avoid diuron PRE. Spray when daytime temps exceed 75 F. Add 1 gal of crop oil per 100 gal. of spray solution. May add 2,4-D or dicamba to this mixture to improve control of emerged plants; follow plant back intervals for 2,4-D or dicamba in this case.
	glufosinate (Liberty 280 SL) 2.34 L (other products are available) MOA 10	29 to 43 fl oz	0.53 to 0.78	Recommended for fields where growers have failed to control glyphosate-resistant horseweed with the early burndown. Best results obtained if sprayed in full sunlight with daytime temperatures above 80 F. If greater than 29 oz/A is applied preplant, the season total applied cannot exceed 72 fl oz/A. Use of at least 15 GPA while applying with medium spray droplet size. Do not spray glufosinate more than twice a year and do not spray within 1.5 hour of sunrise and 1 hour of sunset.

[1]Mode of Action (MOA) code can be used to delay weed resistance by increasing herbicide diversity in a management program.

WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
PREPLANT: AT OR JUST PRIOR TO PLANTING				
Emerged annual weeds and cover crops. Inadequate control of primrose, radish, geranium and resistant pigweed or horseweed often noted.	glyphosate 4.0 SL (3 lb a.e.) 5.4 SL (4 lb a.e.) 5.0 SL (4.17 lb a.e.) 5.5 SL (4.5 lb a.e.) 6.0 SL (5.0 lb a.e.) MOA 9	 32 to 48 fl oz 24 to 36 fl oz 23 to 34 fl oz 22 to 32 fl oz 19 to 29 fl oz	0.75 to 1.13	Apply glyphosate or paraquat in combination with desired residual herbicides at planting. Glyphosate or paraquat may be tank mixed with registered preemergence herbicides applied after planting but before cotton emerges. See suggested rates and precautions on labels of tank-mix partners. Glyphosate or paraquat rates depend upon weed species and size; see labels for recommended rates. Add nonionic surfactant at 2 pt per 100 gal or crop oil concentrate at 1 gal per 100 gal spray mix for paraquat. Need for adjuvants with glyphosate depend upon brand used. Control of mature cover crops: Wheat < 12".: glyphosate 0.75 lb a.e. or paraquat 0.63 lb Wheat > 12".: glyphosate 0.75 lb a.e. or paraquat 0.75 lb Rye < 18".: glyphosate 0.56 lb a.e. or paraquat 0.56 lb Rye > 18": glyphosate 0.75 lb a.e. or paraquat 0.75 lb Paraquat controls mature cover crops (visible seedhead) much more effectively than immature ones. When spraying immediately after rolling rye with seedheads, paraquat (3 SL) at 10 oz/A or glyphosate at 0.56 lb/A is adequate as long as Valor is included in the mixture. Contact your local Extension office for the latest bulletin on this system.
Emerged annual weeds. Does not control immature eveningprimrose, large horseweed, curly dock, swinecress, immature radish, or large grasses.	paraquat (Gramoxone SL) 2SL (Firestorm, Parazone) 3SL MOA 22	 2.5 to 4.0 pt 1.7 to 2.7 pt	0.63 to 1	
Mature primrose and morningglory. Inadequate control of immature radish or grain cover crops.	glufosinate-ammonium (Liberty 280 SL) 2.34 L (other formulations available) MOA 10	29 to 43 fl oz	0.53 to 0.78	Applications may be made prior to planting or emergence. Mix with ammonium sulfate during burndown. Use 15 GPA while generating medium spray droplets. Do not spray glufosinate more than twice a season and DO NOT spray within 1.5 hr of sunrise or 1 hr of sunset.

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WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
PREPLANT INCORPORATED				
Annual grasses, pigweeds, and Florida pusley. Controls glyphosate-resistant Palmer amaranth more effectively than when applied PRE. The addition of a PRE herbicide still needed for Palmer control.	pendimethalin (Prowl) 3.3 EC (Pendimax) 3.3 EC (Prowl H20) 3.8 AS MOA 3	1.2 to 2.4 pt 1.2 to 2.4 pt 2 pt	0.5 to 1 0.5 to 1 0.95	Soil incorporate in top 2 inches within 24 hrs of application. Application within wk of planting suggested. Pendimethalin is less volatile than trifluralin and is a better option if incorporation is delayed. For most soils, 2 pt/A of one of these pendimethalin formulations or 1.5 pt/A of Treflan is suggested.
	trifluralin (Treflan, others) 4.0 EC MOA 3	1 to 2 pt	0.5 to 1	
Glyphosate-resistant Palmer amaranth & yellow nutsedge	fomesafen (Reflex) 2 L + pendimethalin or trifluralin MOA 14 + 3	16 fl oz + see rates above	0.25 + see rates above	Currently a Section 2 (ee) label allows for preplant incorporated application of Reflex in Georgia. Incorporate Reflex mixture to a SHALLOW (2 inch or less) depth while the soil is moist. For Palmer amaranth, less control is noted with incorporated applications of Reflex as compared to PRE applications when PRE applications are activated immediately by irrigation or rainfall; however, less injury potential is usually observed with incorporated applications. Mixtures of Reflex plus a yellow herbicide are as effective as Reflex PRE. Suggest following the split Reflex program below.
SPLIT PROGRAM WITH PREPLANT INCORPORATED (PPI) FOLLOWED BY PREEMERGENCE (PRE) APPLICATIONS				
The **SINGLE MOST EFFECTIVE** approach for the control of Palmer amaranth while also offering the least injury potential from Reflex.	**PPI:** trifluralin or pendimethalin (Treflan) or (Prowl) + fomesafen (Reflex) 2 L **PRE:** fomesafen (Reflex) 2L + acetochlor (Warrant) 3 ME ***OR*** diuron (Direx, diuron) 4 F MOA 3 + 14 + 15 or 7	**PPI:** see rates above + 12 oz **PRE:** 8 to 10 oz + 3 pt ***OR*** 10 to 20 oz	**PPI:** see rates above + 0.19 **PRE:** 0.125 to 0.16 + 1.125 ***OR*** 0.31 to 0.63	PPI: Incorporate Reflex into a moist soil at a maximum depth of 1.5 inches. Plant within 1 week of application/incorporation if possible to extend Palmer control into the crop. PRE: Add a low rate of Gramoxone plus adjuvant if Palmer is emerged.

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WEED	HERBICIDE FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
PREEMERGENCE-BROADLEAF AND GRASS CONTROL				
Control of annual grasses, Palmer amaranth, and tropical spiderwort.	acetochlor (Warrant) 3 ME MOA 15	40 to 48 oz	1 to 1.13	Warrant must be applied in combination with fomesafen (Reflex, others), diuron, or fluometuron depending on Palmer amaranth populations and cotton technology grown. Add Gramoxone and adjuvant if Palmer amaranth is up. Apply within 24 hr of planting.
Annual broadleaf weeds and suppression of annual grasses. More effective than fluometuron on pigweed, less effective on most other broadleaf weeds.	diuron (Direx, diuron) 80 DF (Direx, diuron) 4 L MOA 7	0.38 to 0.78 lb 10 to 20 oz	0.31 to 0.62	Diuron must be applied in combination with fomesafen (Reflex, others) or Warrant depending on Palmer amaranth populations and cotton technology. Add Gramoxone and adjuvant if Palmer amaranth is up. Apply within 24 hr of planting. See label for specific usage rates; in general use lower rates on sandier soils and/or with intense irrigation scheduling. Label restricts uses on sands or soils with <1% organic matter; label also suggest to not use Di-Syston or Thimet.
Annual broadleaf weeds, suppression of annual grasses. The most effective single preemergence material for sicklepod, cocklebur, and morningglory control.	fluometuron (Cotoran) 4 F MOA 7	2 to 3 pt	1 to 1.5	Cotoran must be applied in combination with fomesafen (Reflex, others) or Warrant depending on Palmer amaranth populations and cotton technology. Add Gramoxone and adjuvant if Palmer amaranth is up. Apply within 24 hr of planting. See label for specific rates on your soils; in general use lower rates on sandier soils and/or with intense irrigation. A maximum of 2 pt/A is ideal for most GA soils.
Pigweeds including glyphosate-resistant Palmer amaranth. Good control of yellow nutsedge and wild poinsettia. Good pigweed control even if first rain occurs 15 d after application; however, pigweed that emerged before activation will not be controlled usually.	fomesafen (Reflex) 2 L (other products available) MOA 14	12 to 16 fl oz	0.19 to 0.25	Reflex or generics must be applied in combination with Warrant, diuron, or fluometuron depending on Palmer amaranth populations and cotton technology. Add Gramoxone and adjuvant if Palmer amaranth is up. Apply within 24 hr of planting. Research suggests 12 oz/A is an appropriate rate when mixed with Warrant or diuron in Roundup Ready cotton and 10-12 oz/A is an appropriate rate for these mixtures in cotton tolerant to Liberty. However, on sandy soils with low organic matter the rate may need to be reduced to avoid serious injury. **For PPO-resistance management, make only two applications of Reflex or Valor on the same land over two years.**
Annual grasses, and Florida pusley; suppression of Palmer amaranth.	pendimethalin (Prowl) 3.3 EC (Pendimax) 3.3 EC (Prowl H20) 3.8 AS MOA 3	1.8 to 3.6 pt 1.8 to 3.6 pt 2 to 3 pt	0.75 to 1.5 0.75 to 1.5 0.95 to 1.42	Preemergence applications are less consistent than incorporated treatments; tank mixtures are needed for Palmer. Wet/moist conditions during emergence (rainfall or irrigation) can cause significant plant stunting, leaf/stem malformation, and stem swelling and eventual breaking; especially when used in combination with Reflex or generic. Add Gramoxone if Palmer amaranth is up. Apply within 24 hr of planting.
Controls pigweeds including glyphosate-resistant Palmer amaranth, lambsquarters, prickly sida, spurge, and smartweed. Suppresses morningglory, except tall.	pyrithiobac (Staple LX) 3.2 SL MOA 2	1.7 to 2.1 fl oz	0.0425 to 0.053	Staple is an excellent residual herbicide but cotton injury, especially on irrigated acres, has become a serious concern. Thus, a delayed PRE or early POST use of Staple is being suggested by UGA and can be found on the following page or you can contact your local office for the latest circular. **Palmer amaranth biotypes resistant to Staple are common. For ALS-resistance management, make only one application of Staple and/or Envoke per season.**

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WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
POSTEMERGENCE OVER-THE-TOP BROADLEAF AND GRASS CONTROL FOR ANY CULTIVAR Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control.				
Annual broadleaf weeds. **Poor control** of Palmer amaranth larger than 2 inch.	fluometuron (Cotoran) 4 F MOA 7	2 to 2.5 pt	1 to 1.25	Apply overtop of cotton 3 to 6 in. tall. Add surfactant at 1 qt per 100 gal. **Salvage treatment**. Cotton usually injured, maturity delayed, and yield can be reduced. Rates greater than 1 lb a.i. per acre not advised.
Morningglory (except tall mg), coffee senna, redweed and pigweed < 2 inches, excluding ALS resistant pigweed. Appropriate weed sizes (less than 3 inches) and favorable growing conditions are essential. Provides good to excellent residual control if reaches soil.	pyrithiobac (Staple LX) 3.2 SL (Pyrimax) 3.2 SL MOA 2	2.6 to 3.0 fl oz 2.6 to 3.0 fl oz	0.06 to 0.07	Apply overtop of cotton from cotyledonary stage up to 60 days of harvest. Avoid applying during periods of cool, wet weather. Include nonionic surfactant at 1 qt per 100 gal spray mix. Label allows increasing rate up to 3.8 fl oz but injury is a concern. Label also allows 2 applications per year, not exceeding a total of 5.1 fl oz. Do not mix with grass control herbicides. May tank mix with most insecticides, but do not tank mix with any product containing malathion. **Do not mix with any Dual or Warrant product;** separate applications with Dual or Warrant by 5 or more days. See label for rotational restrictions. **Palmer amaranth biotypes resistant to ALS inhibitors including Staple/Pyrimax and Envoke are present in Georgia. For resistant management, make only one TIMELY application of Staple and/or Envoke per season.**
Annual broadleaf weeds including sicklepod, *Ipomoea* morningglory, and nutsedge. Will not control smallflower morningglory or ALS-resistant pigweed. Also provides residual control of sensitive species if contacts soil and is activated.	trifloxysulfuron (Envoke) 75 WDG MOA 2	0.1 oz	0.0047	Apply overtop after cotton has at least 6 (prefer 7) true leaves up until 60 days of harvest. Direct application on larger cotton for improved weed coverage and less cotton injury. Add nonionic surfactant at 1 qt per 100 gal; do not use other types of adjuvants. May mix with Centric, Karate Z, Denim or Staple, see label. Do not mix with other pesticides including plant growth regulators. In an attempt to avoid the potential for severe injury, do not apply to cotton under stress, such as very dry, wet, or cool conditions. Envoke may be directed to cotton 6 in. or larger at rates of 0.1 to 0.25 oz/A. See label for details and rotational restrictions. Rainfast in 3 hr. **Palmer amaranth biotypes resistant to ALS inhibitors including Envoke and Staple/Pyrimax are present in Georgia. Make only one TIMELY application of Staple and/or Envoke per season.**
Most broadleaf weeds. Poor control of tropic croton, copperleaf and ALS-resistant pigweed. Provides broadleaf residual control of sensitive species if products contact the soil and are activated.	trifloxysulfuron (Envoke) 75 WDG + pyrithiobac (Staple LX) 3.2 SL MOA 2 + 2	0.1 oz + 1.3 to 1.9 fl oz	0.0047 + 0.03 to 0.05	Apply overtop or directed after cotton has at least 6 (prefer 7) true leaves up until 60 days of harvest. Add non-ionic surfactant at 1 qt per 100 gal. spray mix. See comments and restrictions for each product applied alone. To avoid the potential for severe injury, do not apply to cotton under stress, such as very dry, wet, or cool conditions. **Palmer amaranth biotypes resistant to ALS inhibitors including Staple/Pyrimax and Envoke are present in Georgia. Make only one TIMELY application of Staple and/or Envoke per season.**

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WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
POSTEMERGENCE OVER-THE-TOP BROADLEAF AND GRASS CONTROL FOR GLUFOSINATE TOLERANT COTTON Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control.				
Control of pusley, spiderwort, and goosegrass is not consistent, use residual at-plant herbicide. In general, broadleaf weeds should be 3 inches or less and grasses no larger than 2 inch. Excellent control of morningglory including moonflower morningglory. Do not make more than 2 applications per year.	glufosinate-ammonium (Liberty 280 SL) 2.34 L MOA 10	29 to 43 fl oz	0.53 to 0.79	**LIBERTY LINK CULTIVARS:** Can be applied overtop or directed from cotton emergence up to early bloom. On larger cotton, directed application may give better spray coverage on weeds. Apply in a minimum of **15 GPA generating medium size spray droplets**. Do not exceed 43 fl oz/A per application. Also, do not exceed 87 fl oz per acre per season with individual applications of 29 fl oz/A or less and do not exceed 72 oz per acre per season if any individual application greater than 29 oz/A is made. Control is improved with warm temperatures, high humidity, and bright sunlight. Mixtures with residual herbicides are often needed to assist in the control of grasses, pusley, and pigweed. **For Palmer amaranth, apply at least 29 fl oz/A when less than 3 inch; 32 oz/A when 3 inch; 36 oz/A when 4 inch; and 43 oz/A when taller than 4 inch.** **Do not apply Liberty within 1.5 hr of sunrise or 1 hr of sunset.** Adjuvant not needed for in crop use. Do not apply within 70 d of harvest. Rainfast in 4 hr. Do not mix with graminicides.
Staple may improve emerged pigweed control (non ALS-resistant) and provides residual activity on sensitive weeds if spray contacts soil and is activated.	glufosinate-ammonium (Liberty 280 SL) 2.34 L + pyrithiobac (Staple LX) 3.2 SL MOA 10 + 2	29 fl oz + 1.3 to 1.9 fl oz	0.53 + 0.03 to 0.05	**LIBERTYLINK CULTIVARS:** Apply topically from full cotyledonary cotton through the 7 leaf stage; suggest sloppy directed application after that time to improve weed control and reduce injury potential. Do not mix with metolachlor products, Warrant, or any other adjuvant as injury may be significant. **Do not apply Liberty within 1.5 hr of sunrise or 1 hr of sunset.**
Residual herbicides provide control of grasses, spiderwort, and pigweeds if spray contacts soil and is activated.	glufosinate-ammonium (Liberty 280 SL) 2.34 L + S-metolachlor (Dual Magnum) 7.62EC OR acetochlor (Warrant 3 ME) MOA 10 + 15	29 to 32 fl oz + 1 pt OR 3 pt	0.53 to 0.58 + 0.95 OR 1.125	**LIBERTYLINK CULTIVARS:** Apply topically once cotton is fully emerged through 7 leaf stage; suggest sloppy directed application after that time to improve weed control and reduce injury potential. Warrant can be applied through bloom. Dual Magnum can be applied overtop until 100 day before harvest and directed until 80 day before harvest. Expect some leaf speckling or burn, cotton should recover quickly. Avoid applications when cotton is covered with dew. Palmer amaranth needs to be no more than 3 inches at time of application. Apply in a minimum of 15 GPA generating medium size spray droplets. **Do not apply Liberty within 1.5 hr of sunrise or 1 hr of sunset.**
POSTEMERGENCE OVER-THE-TOP BROADLEAF AND GRASS CONTROL FOR PHYTOGEN WIDESTRIKE COTTON Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control.				
Glyphosate-resistant Palmer amaranth in Widestrike cotton.	glufosinate-ammonium (Liberty 280 SL) 2.34 L	29 fl oz	0.53	**Phytogen cultivars with the Widestrike trait** are tolerant to Liberty. Tolerance in these cultivars is not complete, and varying levels of crop injury are often noted. Greater injury can be expected when Liberty is mixed with AMS, mixed with other pesticides, or applied at higher rates. **Grower assumes the liability of crop injury.** Make no more than two topical applications with both applications being made prior to 8 leaf cotton. **See restrictions above on Liberty in LibertyLink cotton.**

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WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
POSTEMERGENCE OVER-THE-TOP BROADLEAF AND GRASS CONTROL FOR ROUNDUP READY FLEX COTTON Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control.				
Controls most annual weeds; exceptions include glyphosate-resistant Palmer amaranth and horseweed, dayflower, Florida pusley, tropical spiderwort, doveweed and hemp sesbania. Timely applications critical for purslane and morningglory. Conventional at plant and directed herbicide options must be used even in a Roundup Ready Flex program.	glyphosate 4.0 SL (3 lb a.e.) 5.4 SL (4 lb a.e.) 5.0 SL (4.17 lb a.e.) 5.5 SL (4.5 lb a.e.) 6.0 SL (5.0 lb a.e.) MOA 9	 32 to 48 fl oz 24 to 36 fl oz 23 to 34 fl oz 22 to 32 fl oz 19 to 29 fl oz	0.75 to 1.12	**ROUNDUP READY FLEX CULTIVARS** For WeatherMax or PowerMax, they may be applied overtop or directed to Flex cotton anytime from cotton emergence until 7 days prior to harvest. The maximum rate for any single application between emergence and 60% open bolls is 32 fl oz (1.12 lb a.e.). Do not exceed a total of 128 fl oz (4.5 lb a.e.) applied from emergence through 60% open bolls. Do not exceed a maximum of 44 fl oz (1.55 lb a.e.) applied between layby and 60% open bolls. Do not exceed a maximum of 44 fl oz between 60% open bolls and harvest. Directed applications may be more effective in larger cotton to allow better coverage of weeds under canopy or to allow for tank mixes with other herbicides.
Compared to glyphosate alone, tank mix provides residual control of annual grasses, pigweeds including glyphosate-resistant Palmer amaranth, and tropical spiderwort if the acetochlor contacts the soil and is activated.	glyphosate + acetochlor (Warrant) 3 ME MOA 9 + 15	glyphosate + 3 pt	0.75 to 1.12 + 1.125	**ROUNDUP READY FLEX CULTIVARS** The label allows a topical application once cotton is completely emerged up until it reaches bloom; however, UGA research suggest topical applications be made from emergence through the 7 leaf stage of cotton development with directed applications being made afterward. A topical and directed application may be made as long as Warrant was not applied PRE; if Warrant was applied PRE then one POST option can be made. Use labeled loaded glyphosate formulation and do not add adjvuants or other pesticides including Staple. Avoid heavy dew on cotton plant and extreme, hot conditions.

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WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
POSTEMERGENCE OVER-THE-TOP BROADLEAF AND GRASS CONTROL FOR ROUNDUP READY FLEX COTTON Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control.				
Compared to glyphosate alone, tank mix provides residual control of annual grasses, pigweeds including glyphosate-resistant Palmer amaranth, doveweed, Florida pusley, and tropical spiderwort and suppression of yellow nutsedge if the metolachlor contacts the soil and is activated.	glyphosate + S-metolachlor (Dual Magnum) 7.62 EC other products available MOA 9 + 15	glyphosate + 1 pt	0.75 to 1.12 + 0.95	**ROUNDUP READY FLEX CULTIVARS** Dual Magnum can be applied overtop of cotton from emergence until 100 days of harvest and directed until 80 days of harvest. Suggest making topical applications until 7 leaf cotton and then making sloppy directed applications to improve weed control and reduce crop injury. Dual rate can be increased to 1.33 pt/A if needed. Do not mix with Staple/Pyrimax and do not apply within 5 d of Staple/Pyrimax. Do not add adjuvants and do not mix with other pesticides. Avoid dew on cotton plant and extreme, hot conditions.
	glyphosate + S-metolachlor (Sequence) 5.25 L	2.5 pt	0.7 + 0.94	Apply from cotyledon stage cotton to the 10 leaf stage (not to exceed 12 inches tall) of cotton. Do not harvest within 100 days of application. Do not add adjuvants and do not mix with other pesticides. Avoid dew on cotton plant and extreme, hot conditions.
Staple improves control of hemp sesbania, morningglory, tropical spiderwort, and glyphosate- resistant Palmer amaranth. Staple will provide residual control of pigweeds, prickly sida, smartweed, spurred anoda, and velvetleaf if it contacts the soil and is activated.	glyphosate + pyrithiobac (Staple LX) 3.2 SL (Pyrimax) 3.2 SL MOA 9 + 2	glyphosate + 1.3 to 3.0 fl oz 1.3 to 3.0 fl oz	0.75 to 1.12 + 0.03 to 0.07	**ROUNDUP READY FLEX CULTIVARS** Apply overtop from cotton cotyledonary stage until 60 days prior to harvest; however, sloppy directed applications encouraged after the 7 leaf stage to improve weed control and reduce injury potential. Do not mix with any Dual or metolachlor product or Warrant. For Palmer amaranth, apply Staple at 2.6 to 3 oz/A when Palmer is 2 inches or less; rate can be increased to 3.8 oz/A but cotton injury is a concern. **Palmer amaranth biotypes with resistance to glyphosate AND ALS chemistry (Staple, Envoke, etc.) have been confirmed in Georgia. This mixture will not impact Palmer amaranth if it is resistant to both glyphosate and ALS-herbicide chemistry.** **Make only one TIMELY application of Staple/Pyrimax or Envoke per season.**

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WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
POSTEMERGENCE OVER-THE-TOP BROADLEAF AND GRASS CONTROL FOR ROUNDUP READY FLEX COTTON (continued) Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control.				
Envoke will improve control of *Ipomoea* morningglory and nutsedge	glyphosate + trifloxysulfuron (Envoke) 75 WDG MOA 9 + 2	glyphosate + 0.1 oz	0.75 to 1.12 + 0.0047	**ROUNDUP READY FLEX CULTIVARS** Tank mix can be applied topically from the 7 leaf until 60 days of harvest; however, injury is a concern and UGA suggest sloppy directed applications be used. Rainfast in 3 hr. Try this mixture on limited acreage only as injury can be significant. **Palmer amaranth biotypes with resistance to glyphosate AND ALS chemistry (Staple, Pyrimax, Envoke, etc.) have been confirmed in Georgia. This mixture will not impact Palmer amaranth if it is resistant to both glyphosate and ALS-herbicide chemistry.** **Make only one TIMELY Envoke and/or Staple/Pyrimax application per season.**
Volunteer Roundup Ready corn	glyphosate + clethodim (Select) 2 EC (Select Max) 0.97 EC MOA 9 + 1	glyphosate + 4 to 8 fl oz 6 to 12 fl oz	0.75 to 1.12 + 0.06 to 0.12 0.05 to 0.09	**ROUNDUP READY FLEX CULTIVARS** For corn up to 12 in. tall, apply 4 to 6 oz of Select or 6 oz of Select Max; for corn up to 24 in. tall, apply 6 to 8 oz of Select or 9 oz of Select Max; for corn up to 36 in. tall, apply 12 oz of Select Max. Add 2.5 lb per acre ammonium sulfate or equivalent and make sure glyphosate brand used contains adjuvant.
	glyphosate + fluazifop-p-butyl (Fusilade DX) 2 EC MOA 9 + 1	glyphosate + 4 to 6 fl oz	0.75 to 1.12 + 0.06 to 0.09	**ROUNDUP READY FLEX CULTIVARS** Apply 4 oz Fusilade for corn less than 12 in. Increase rate to 6 oz for corn up to 24 in. Add 0.25% by volume of crop oil concentrate.
	glyphosate + quizalofop-p-ethyl (Assure II) 0.88 EC MOA 9 + 1	glyphosate + 5 to 8 fl oz	0.75 to 1.12 + 0.03 to 0.05	**ROUNDUP READY FLEX CULTIVARS** Apply Assure at 4 oz to corn up to 12 in., 5 oz for corn up to 18 in., and 8 oz to corn up to 30 in. Add 0.125% nonionic surfactant by volume.
Volunteer Roundup Ready soybean	glyphosate + trifloxysulfuron (Envoke) 75 WDG MOA 9 + 2	glyphosate + 0.1 oz	0.75 to 1.12 + 0.0047	**ROUNDUP READY FLEX CULTIVARS** See comments above on glyphosate plus Envoke. Cotton should have at least 7 leaves and soybean should have no more than 4 to 5 trifoliate leaves. Not adequately effective on soybean with the STS trait. Consider the addition of Cotoran PRE at planting to control soybean. **Make only one TIMELY Envoke and/or Staple/Pyrimax application per season.**

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		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
POSTEMERGENCE OVER-THE-TOP GRASS CONTROL FOR ANY COTTON CULTIVAR Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control.				
Annual grasses	clethodim (Select, others) 2 EC (Select Max) 0.97 EC (TapOut) 0.97 EC MOA 1	6 to 8 fl oz 9 to 16 fl oz 9 to 16 fl oz	0.09 to 0.13 0.07 to 0.12 0.07 to 0.12	Apply to actively growing grasses not under stress. Add crop oil concentrate at 1 qt per acre for Select. To Select Max, add nonionic surfactant at 1 qt per 100 gal solution or crop oil concentrate at 1 gal per 100 gal solution. Mixtures with other herbicides may reduce grass control. A second application may be made if needed. Many generic brands of clethodim are available.
	fluazifop p-butyl (Fusilade DX) 2 EC MOA 1	8 to 12 fl oz	0.125 to 0.188	Apply to actively growing grasses not under stress. Apply with crop oil concentrate (preferred) at 1 gal per 100 gal solution or nonionic surfactant at 1 qt per 100 gal solution. Mixtures with other herbicides may reduce grass control. A second application may be made.
	quizalofop p-ethyl (Assure II) 0.88 EC MOA 1	7 to 8 fl oz	0.05 to 0.06	Apply to actively growing grasses not under stress. Apply with crop oil concentrate at 1 gal per 100 gal solution. Tank mixtures with other herbicides may reduce grass control. A second application may be made.
	sethoxydim (Poast) 1.53 EC (Poast Plus) 1.0 EC MOA 1	16 fl oz 24 fl oz	0.19	Apply to actively growing grasses not under stress. Add crop oil concentrate at 1 qt per acre. Tank mixtures with other herbicides may reduce grass control. A second application may be made.
Rhizome johnsongrass and Bermuda grass	clethodim (Select, others) 2 EC (Select Max) 0.97 EC (TapOut) 0.97 EC MOA 1	8 to 16 fl oz 12 to 32 fl oz 12 to 32 fl oz	0.13 to 0.25 0.09 to 0.24 0.09 to 0.24	Apply to actively growing johnsongrass 12 to 24 in. tall or to bermudagrass with runners up to 6 in. A second application of 8 to 16 oz of Select or 12 to 32 oz of Select Max may be applied to bermudagrass when regrowth is up to 6 in. For johnsongrass, a second application of 6 to 8 oz of Select or 9 to 24 oz of Select Max may be applied when regrowth is 6 to 18 in. Add crop oil concentrate at 1 qt per acre to Select. To Select Max, add nonionic surfactant at 1 qt per 100 gal solution or crop oil concentrate at 1 gal per 100 gal solution. Do not mix with other herbicides.
	fluazifop p-butyl (Fusilade DX) 2 EC MOA 1	10 to 12 fl oz	0.156 to 0.188	Apply when johnsongrass is 8 to 18 inches or when bermudagrass runners are 4 to 8 inches. If needed, make a second application of 8 fl oz/A when johnsongrass regrowth or new plants are 6 to 12 inches or when bermudagrass stolon (runner) regrowth or new plants are 3 to 6 inches. Apply with crop oil concentrate at 1 gal per 100 gal solution Do not mix with other herbicides.
	quizalofop p-ethyl (Assure II) 0.88 EC MOA 1	10 fl oz	0.07	Apply when johnsongrass is 10 to 24 inches or bermudagrass runners are 3 to 6 inches. A second application for treating regrowth or new plants can be made with 7 fl oz per acre when johnsongrass reaches 6 to 10 inches or bermudagrass reaches 3 to 6 inches. Apply with crop oil concentrate at 1 gal per 100 gal solution. Do not mix with other herbicides.

[1]Mode of Action (MOA) code can be used to delay weed resistance by increasing herbicide diversity in a management program.

WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
POSTEMERGENCE DIRECTED- ANY COTTON CULTIVAR Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control.				
Effective control of many broadleaf weeds and yellow nutsedge. Grasses should be 1 inch or less. Also provides residual control of many weeds. **Diuron plus MSMA is the best option to control emerged glyphosate-resistant Palmer amaranth.** **Valor provides the greatest level of residual pigweed control.**	diuron (Direx, Diuron, other)4L + MSMA (several brands) 6.0 lb/gal 6.6 lb/gal MOA 7 + 17	1.6 to 2.4 pt + 2 pt 2 pt	0.8 to 1.2 + 1.5 to 1.65	Apply as directed spray to cotton at least 12 inches tall. Addition of adjuvant strongly encouraged. Label prohibits use on sand or loamy sand soils, or any soils with less than 1% organic matter. Higher rates of diuron provide greater residual weed control but extended rotational concerns. <u>If soil type allows, use at least 2 pt/A of diuron for control of emerged Palmer amaranth</u>. Label prohibits applying MSMA after first bloom. The addition of Envoke, Aim, or ET will improve morningglory control. Envoke at 0.1 to 0.15 oz/A poses no additional injury concern and the mixture can be applied to 12 inch or larger cotton. For Aim or ET at 0.5 to 1 fl oz/A, cotton should be at least 20 inches tall having at least 3 inches of bark with spray not contacting green portion of stem. Aim will also improve spiderwort control. The addition of S-metolachlor or Warrant with diuron + MSMA is recommended for managingtropical spiderwort.
	diuron + linuron (Layby Pro) 4 L + MSMA (several brands) 6.0 lb/gal 6.6 lb/gal MOA 7 + 7 + 17	2 pt + 2.67 pt 2.5 pt	0.5 + 0.5 + 1.5 to 1.65	Apply as a directed spray to cotton at least 18 in. tall. Add crop oil concentrate at 1 gal per 100 gal spray mix. Label prohibits use on sand or loamy sand soils, or on any soil with less than 1% organic matter. Label prohibits applying MSMA after first bloom.
	flumioxazin (Valor SX) 51 WDG + MSMA (several brands) 6.0 lb/gal 6.6 lb/gal MOA 14 + 17	2 oz + 2.67 pt 2.5 pt	0.064 + 2	Apply as a directed spray to cotton at least 18 in tall. Direct spray to the lower 2 inches of the cotton stem and do not contact the green portion of the cotton stem. May apply to 6 inch cotton under a hood. Add nonionic surfactant at 1 qt per 100 gal spray mix. DO NOT use crop oil concentrate, methylated seed oil, organo-silicone adjuvant, or any adjuvant containing any of these. Label prohibits applying MSMA after first bloom. IN HOODED APPLICATIONS when <u>no</u> contact of the cotton crop occurs: The addition of S-metolachlor or Warrant is recommended for managing tropical spiderwort. **For PPO-resistance management, make only two applications of Valor or Reflex in two years.**

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WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
POSTEMERGENCE DIRECTED- ANY COTTON CULTIVAR (continued) Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control.				
Currently, the single best layby mixture for both control of emerged glyphosate-resistant Palmer amaranth and extended residual control.	diuron (Direx, Diuron, other)4L + flumioxazin (Valor SX) 51 WDG + MSMA (several brands) 6.0 lb/gal 6.6 lb/gal MOA 7 + 14 + 7	2.0 pt + 1 to 2 oz + 2.67 pt 2.5 pt	1 + 0.03 to 0.06 + 2	**See restrictions for each product applied alone**. Cotton should be at least 20 in tall. Apply as directed spray to the lower 2 inches of the cotton stem. Experiment with this mixture on limited acreage as crop injury is of some concern. Valor may not improve control of emerged plants but will provide excellent residual control. Add nonionic surfactant at 1 qt per 100 gal spray mix. DO NOT use crop oil concentrate, methylated seed oil, organo-silicone adjuvant, or any adjuvant containing any of these. Label prohibits applying MSMA after first bloom.
Effective control of many broadleaf weeds, yellow nutsedge, and small annual grasses. Also provides residual control of many weeds.	fluometuron (Cotoran) 4 F + MSMA (several brands) 6.0 lb/gal 6.6 lb/gal MOA 7 + 17	2.0 to 3.2 pt + 2.67 pt 2.5 pt	1 to 1.6 + 2	Apply as a directed spray to cotton at least 3 in. tall. Label prohibits applying MSMA after first bloom. The addition of S-metolachlor or Warrant is recommended for managing tropical spiderwort and Palmer amaranth. Much less effective than diuron + MSMA on emerged pigweed.
Emerged broadleaf weeds, yellow nutsedge, and very small annual grasses. Limited residual control and often poor control of emerged Palmer.	lactofen (Cobra) 2 EC + MSMA (several brands) 6.6 lb/gal MOA 14 + 17	10 to 12.5 fl oz + 2.5 pt	0.16 to 0.2 + 2.0	Apply as directed spray or with hoods after cotton is 12 inches tall. Contact only lower woody portion of cotton stem. Add crop oil or nonionic surfactant according to labels. Label prohibits applying MSMA after first bloom. Do not apply lactofen within 70 days of harvest. Much less effective than diuron + MSMA on emerged pigweed.
Effective control of many broadleaf weeds, yellow nutsedge, and small annual grasses. Limited residual control.	linuron (Linex) 4 L + MSMA 6.0 lb/gal 6.6 lb/gal MOA 7 + 17	2 pt + 2.67 2.5	1 + 2	Apply as directed spray to cotton that is at least 20 inches tall. See precautions on label. Add 2 qt nonionic surfactant per 100 gal spray solution. Label prohibits applying MSMA after first bloom. Any crop may be planted 4 months after application except for cereals OTHER THAN barley, oats, rye, and wheat.
Effective control of many broadleaf weeds, yellow nutsedge, and small annual grasses. Limited residual control especially on pigweeds.	prometryn (Caparol, others) 4 F + MSMA (several brands) 6.0 lb/gal 6.6 lb/gal MOA 5 + 17	1.3 to 2.4 pt + 2.67 pt 2.5 pt	0.65 to 1.2 + 2	Apply as directed spray. Use 1.3 pt/A Caparol in 8 to 12 in. cotton and up to 2.4 pt/A in cotton at least 12 in. Add nonionic surfactant at 2 q t per 10 0 gal spray solution. Label prohibits applying MSMA after first bloom. The addition of Envoke will improve broadleaf control, especially morningglory. Envoke at 0.1 to 0.15 oz/A poses no additional injury concern and the mixture can be applied to 12 inch or larger cotton. The addition of Dual Magnum or Warrant with improves tropical spiderwort and Palmer amaranth residual control. Much less effective than diuron + MSMA on emerged pigweed.

[1]Mode of Action (MOA) code can be used to delay weed resistance by increasing herbicide diversity in a management program.

WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
POSTEMERGENCE DIRECTED- ANY COTTON CULTIVAR (continued) Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control.				
Effective control of many broadleaf weeds, yellow nutsedge, and small annual grasses. Excellent residual control of sensitive species.	prometryn + trifloxysulfuron (Suprend) 80 WDG + MSMA (several brands) 6.0 lb/gal 6.6 lb/gal MOA 5 + 2+ 17	 1 to 1.25 lb + 2.67 pt 2.5 pt	0.8 to 1 + 0.007 to 0.009 + 2	Apply as directed spray in <u>cotton at least 8 in tall</u>. Add nonionic surfactant at 1 qt per 100 gal spray mix. See rotation restrictions on label. Label prohibits applying MSMA after first bloom. Do not exceed 0.0188 lb a.i./acre per year of trifloxysulfuron from the combined use of Envoke and Suprend. Suprend is formulated as 79.3% prometryn plus 0.7% trifloxysulfuron.
POSTEMERGENCE DIRECTED- ROUNDUP READY FLEX CULTIVARS ONLY Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control.				
Controls most annual weeds; exceptions include glyphosate-resistant Palmer amaranth, dayflower, doveweed, Florida pusley, tropical spiderwort, and hemp sesbania. Timely application is critical for controlling morningglory and purslane.	glyphosate 4.0 SL (3 lb a.e.) 5.4 SL (4 lb a.e.) 5.0 SL (4.17 lb a.e.) 5.5 SL (4.5 lb a.e.) 6.0 SL (5.0 lb a.e.) MOA 9	 32 to 48 fl oz 24 to 36 fl oz 23 to 34 fl oz 22 to 32 fl oz 19 to 29 fl oz	0.75 to 1.12	**ROUNDUP READY <u>FLEX</u> CULTIVARS** **Glyphosate should never be applied alone but label allows** directed application to Flex cotton up to 7 days prior to harvest. Contact with the RR Flex cotton plants is not of concern; the primary reason to direct is to obtain better coverage of weeds under the crop canopy. At layby, conventional herbicide chemistry is STRONGLY suggested. However, if one choices to use glyphosate then other herbicides, in addition to glyphosate, are recommended to aid in resistance management and to improve weed control. **A sound management program must be followed for managing glyphosate-resistant Palmer amaranth. Obtain programs from the local Extension office or at gaweed.com**
Warrant does not improve control of emerged weeds, but can give residual control of annual grasses, pigweeds, and tropical spiderwort.	glyphosate + acetochlor (Warrant) 3.0 ME MOA 9 + 15	see glyphosate + 3 pt	0.75 to 1.12 + 1.125	**ROUNDUP READY FLEX CULTIVARS** Can be directed to cotton up to first bloom. Add surfactant according to label of glyphosate brand used. See comments for glyphosate applied alone.
Mixture improves control of larger morningglory and tropical spiderwort. Provides no residual weed control.	glyphosate + carfentrazone (Aim EC) 2 EC MOA 9 + 14	see glyphosate + 0.8 to 1.6 fl oz	0.75 to 1.12 + 0.013 to 0.025	**ROUNDUP READY FLEX CULTIVARS** <u>Cotton should be at least 20 in. tall.</u> Extreme care should be exercised in application; see directions and precautions on the Aim label. Contact on green stem will lead to severe injury. Avoid contact of the spray with desirable vegetation. See remarks for glyphosate applied alone.

[1]Mode of Action (MOA) code can be used to delay weed resistance by increasing herbicide diversity in a management program.

WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
POSTEMERGENCE DIRECTED- ROUNDUP READY FLEX CULTIVARS ONLY (continued) Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control.				
Mixture improves morningglory and glyphosate-resistant Palmer amaranth control and provides residual control of small- seeded broadleaf weeds, such as pigweed. The tank mix may give less grass control than glyphosate alone.	glyphosate + diuron (Direx, Diuron) 4 L MOA 9 + 14	see glyphosate + 1 to 1.5 pt	0.75 to 1.12 + 0.5 to 0.75	**ROUNDUP READY FLEX CULTIVARS** Use 1 pt of Direx or diuron on cotton 8 to 12 inches and up to 1.5 pt of diuron on cotton greater than 12 inches. DO NOT reduce the rate of glyphosate because of the potential for antagonism. See diuron rotational restrictions.
Mixture improves morningglory and tropical spiderwort control and provides residual control of broadleaf weeds including pigweeds, purslane, and Florida pusley. Poor control of glyphosate-resistant Palmer amaranth > than 1".	glyphosate + flumioxazin (Valor SX) 51 WDG MOA 9 + 14	see glyphosate + 1 to 2 oz	0.75 to 1.12 + 0.031 to 0.063	**ROUNDUP READY FLEX CULTIVARS** Cotton should be at least 18 inches. Direct spray to the lower 2 inches of cotton stem; minimize cotton contact. Do not allow spray to contact green portion of stem. Use glyphosate brand with surfactant included and do not add any additional product. DO NOT use crop oil concentrate, methylated seed oil, organo-silicone adjuvants, or any adjuvant product containing these. See comments for glyphosate applied alone.
Mixture improves morningglory control and provides residual control of sensitive species. The tank mix may give less grass control than glyphosate alone.	glyphosate + prometryn (Caparol) 4 F MOA 9 + 5	see glyphosate + 1 to 2 pt	0.75 to 1.12 + 0.5 to 1	**ROUNDUP READY FLEX CULTIVARS** Cotton should be at least 8 inch for Caparol rate between 1 and 1.3 pt and at least 12 inch for Caparol rate above 1.3 pt. Add surfactant only if glyphosate brand requires it. See comments for glyphosate applied alone. DO NOT reduce the rate of glyphosate because of the potential for antagonism.
Mixture improves control of larger morningglory. Will provide no residual weed control.	glyphosate + pyraflufen ethyl (ET) 0.208 L MOA 9 + 14	see glyphosate + 0.5 to 1.0 fl oz	0.75 to 1.12 + 0.0008 to 0.0016	**ROUNDUP READY FLEX CULTIVARS** <u>Cotton should be at least 20 in. tall.</u> Exercise extreme care with this application; see directions and precautions on the ET label. Contact on green stem will lead to severe injury. Avoid contact of the spray with desirable vegetation. See remarks for glyphosate applied alone.
Pyroxasulfone is effective on small seeded grass and broadleaf weeds including Palmer.	glyphosate + pyroxasulfone (Zidua) 85 DF MOA 9 + 15	see glyphosate + 0.75 to 1.5 oz/A	0.75 to 1.12 + 0.04 to 0.08	Mixture can be directed to cotton from 7- leaf to 1st bloom. Label prohibits application to coarse-textured soils.

[1]Mode of Action (MOA) code can be used to delay weed resistance by increasing herbicide diversity in a management program.

WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
POSTEMERGENCE DIRECTED- ROUNDUP READY FLEX CULTIVARS ONLY (continued) Application of postemergence herbicide treatments to moisture stressed weeds usually results in poor control.				
S-metolachlor does not improve control of emerged weeds, but can give residual control of annual grasses, pigweed species, doveweed, tropical spiderwort and other dayflower species plus suppression of yellow nutsedge.	glyphosate + S-metolachlor (Dual Magnum) 7.62EC (Brawl) 7.62 EC MOA 9 + 15	see glyphosate + 1 to 1.33 pt 1 to 1.33 pt	0.75 to 1.12 + 0.95 to 1.27	**ROUNDUP READY FLEX CULTIVARS** Can be applied to cotton 3 in. tall through 80 days prior to harvest. Do not apply to sands or loamy sand soils.
	glyphosate + S-metolachlor (Sequence) 5.25 L MOA 9 + 15	see glyphosate + 2.5 pt	0.70 + 0.94	**ROUNDUP READY FLEX CULTIVARS** Direct to cotton up to 12 in. tall and minimize contact with the cotton stems and leaves. Do not add adjuvants or mix with any other product.
Mixing Envoke with glyphosate improves *Ipomoea* morningglory and nutsedge control and provides some residual control of sensitive species.	glyphosate + trifloxysulfuron (Envoke) 75 DF MOA 9 + 2	see glyphosate + 0.1 to 0.2 oz	0.75 to 1.12 + 0.005 to 0.009	**ROUNDUP READY FLEX CULTIVARS** Direct to cotton from 6 in tall through layby. Add nonionic surfactant according to Envoke label. **Palmer amaranth biotypes with resistance to glyphosate AND ALS chemistry (Staple, Envoke, etc.) have been confirmed in Georgia. This mixture may not impact Palmer amaranth if it is resistant to both glyphosate and ALS-herbicide chemistry.**
Mixing Suprend with glyphosate improves control of morningglory, pigweeds, and nutsedge. Also provides residual weed control of sensitive species.	glyphosate + prometyrn + trifloxysulfuron (Suprend) 80 WDG MOA 9 + 5 + 2	see glyphosate + 1 to 1.25 lb	0.75 to 1.12 + 0.8 to 0.1 + 0.007 to 0.009	**ROUNDUP READY FLEX CULTIVARS** Direct to cotton from 6 in tall. Add surfactant according to label of glyphosate brand used. See precautions and rotational restrictions on Suprend label.

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WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
POSTEMERGENCE-HOODED SPRAYER				
Controls most annual weeds; exceptions include glyphosate-resistant Palmer amaranth, dayflower, doveweed, Florida pusley, tropical spiderwort, and hemp sesbania. Timely application is critical for controlling morningglory and purslane.	glyphosate 4.0 SL (3 lb a.e.) 5.4 SL (4 lb a.e.) 5.0 SL (4.17 lb a.e.) 5.5 SL (4.5 lb a.e.) 6.0 SL (5.0 lb a.e.) MOA 9	 32 to 48 fl oz 24 to 36 fl oz 23 to 34 fl oz 22 to 32 fl oz 19 to 29 fl oz	0.75 to 1.12	In non-Roundup Ready cotton, hoods should be kept as close to the ground as possible. Do not allow the spray to contact stems or foliage of non-Roundup Ready cotton. Apply in 5 to 10 GPA at a maximum of 25 PSI. Do not exceed 5 MPH. Suggest that cotton be at least 8 inches tall. Glyphosate is especially effective for prostrate, running species such as citron, burgherkin, and annual grasses. See label of brand used for adjuvant recommendations and use of ammonium sulfate. Other herbicides such as Aim, Caparol, diuron, ET, or Valor may be mixed with certain glyphosate formulations to improve burndown in larger cotton. Caparol, Valor or diuron will also offer residual weed control for several troublesome weeds. Grass control may be reduced with tank mixes of glyphosate plus Caparol or diuron.
Annual grass and broadleaf weeds; suppression of nutsedge. *Mixtures with diuron would be the most effective option to control emerged pigweed and spiderwort in row middles.*	paraquat (Gramoxone SL) 2 SL MOA 22	19 to 38 fl oz	0.3 to 0.6	DO NOT CONTACT COTTON STEMS OR FOLIAGE. Apply in a minimum 15 GPA at a maximum of 25 PSI. Do not exceed 5 MPH. Hoods should be kept as close to the ground as possible. Cotton should be at least 8 inches. Add nonionic surfactant at 2 pt per 100 gal. of spray mix or crop oil concentrate at 1 gal. per 100 gal spray mix. Caparol or diuron (Direx, diuron) may be mixed with paraquat. Tank mixes are usually more effective.
Largest Palmer in field should be no more than 3" when treated. In general, broadleaf weeds should be 3 inches or less and grasses no larger than 2 inch. Excellent control of morningglory including moonflower morningglory.	glufosinate-ammonium (Liberty 280 SL) 2.34 L MOA 10	29 to 43 fl oz	0.53 to 0.78	On non-glufosinate-tolerant cotton, keep hoods close to ground and avoid contact with cotton. Suggest cotton be at least 8 inches. The addition of diuron or other residual product suggested. Adjuvant not needed. **For maximum activity, wait until 1.5 hours after sunrise to begin spraying and stop at least 1 hour before sunset.** Rainfast within 4 hours. Do not apply within 70 days of harvest. Control is improved with warm temperatures, high humidity, and bright sunlight. Apply in a minimum of **15 GPA generating medium size droplets**. Do not exceed 5 MPH. Diuron plus MSMA is more effective than Liberty or Liberty mixtures in controlling Palmer.

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WEED	HERBICIDE, FORMULATION, and MODE OF ACTION CODE[1]	BROADCAST RATE/ACRE		REMARKS AND PRECAUTIONS
		AMOUNT OF FORMULATION	POUNDS ACTIVE (AI or AE)	
HARVEST AID				
Mature morningglory	carfentrazone-ethyl (Aim) 2 EC MOA 14	up to 1.5 fl oz	up to 0.024	Apply as a harvest aid when 60 to 70% of the cotton bolls are open AND when the morningglory are mature (seedpods are visible). May be an additive with other defoliants – see label. See label for addition of adjuvant. See cotton defoliation section.
Mature morningglory	pyraflufen ethyl (ET) 0.208 EC MOA 14	up to 2.75 fl oz	up to 0.0044	Apply as a harvest aid when 60 to 70% of the cotton bolls are open AND when the morningglory are mature (seedpods are visible). May be an additive with other defoliants – see label. See label for addition of adjuvant. See cotton defoliation section.
Desiccation of most weeds. Regrowth of many weeds occurs soon after application.	paraquat (Gramoxone Inteon) 2SL MOA 22	16 to 32 fl oz	0.25 to 0.5	Defoliate cotton as normal. After at least 75% of bolls are open, the remainder of bolls expected to harvest are mature, and most of the cotton leaves have dropped, apply paraquat in a minimum of 20 GPA. Add nonionic surfactant at 1 pt per 100 gal spray mix. Wait 3 to 5 days and pick the cotton as soon as possible. Expect additional trash. An additional option is to add 2 to 6 oz of Gramoxone Inteon with standard defoliation mixtures. Be aware of potential pine tree injury with drift. Generic brands of paraquat containing 3 lb active per gallon may be labeled. These products would be applied at 11 to 21 fl oz for 0.25 to 0.5 lb active equivalent. See cotton defoliation section.
Annual grasses and broadleaf weeds	glyphosate 4.0 SL (3 lb a.e.) 5.4 SL (4 lb a.e.) 5.0 SL (4.17 lb a.e.) 5.5 SL (4.5 lb a.e.) 6.0 SL (5.0 lb a.e.) MOA 9	 32 to 64 fl oz 24 to 48 fl oz 23 to 46 fl oz 22 to 44 fl oz 19 to 38 fl oz	0.75 to 1.5	Apply after at least 60% of bolls are open in non-Roundup Ready cotton. May be tank mixed with defoliants. See label and defoliant section. Include nonionic surfactant according to the label of glyphosate brand used. May apply in Roundup Ready Flex cotton up to 7 days before harvest. See cotton defoliation section.

[1]Mode of Action (MOA) code can be used to delay weed resistance by increasing herbicide diversity in a management program.

[1] The numerical system to describe modes of action is taken from the Weed Science Society of America. Modes of action are as follows:

1	ACCase inhibition
2	ALS inhibition
3	Microtubule assembly inhibition
4	Synthetic auxin
5	Photosystem II, different binding behavior than groups 6 and 7
6	Photosystem II, different binding behavior than groups 5 and 7
7	Photosystem II, different binding behavior than groups 5 and 6
8	Inhibition of lipid synthesis – not ACCase inhibition
9	EPSP synthase inhibition
10	Glutamine synthetase inhibition
12	Inhibition of carotenoid biosynthesis at PDS
13	Inhibition of carotenoid biosynthesis, unknown target
14	PPO inhibition
15	Inhibition of very long-chain fatty acids
17	Unknown mode of action
19	Auxin transport inhibition
22	Photosystem I electron diversion
27	Inhibition of HPPD

WEED RESPONSE TO BURNDOWN HERBICIDES USED IN COTTON

Weed Species	Burndown Treatment [1]									
	2,4-D [3]	glyphosate	glyphosate acid [2] + 2,4-D [3]	glyphosate acid [2] + Clarity [4]	glyphosate acid [2] + Aim or ET	glyphosate acid [2] + diuron [7]	glyphosate acid [2] + Harmony Extra [5]	glyphosate acid [2] + Valor SX [6]	paraquat	paraquat + Direx [7]
GRASSES / SEDGES										
annual bluegrass	N	E	E	E	E	E	E	E	G-E	E
bermudagrass	N	F	F	F	F	F	F	F	P	P
crabgrass	N	E	G-E	E	E	G	E	E	F-G	G
goosegrass	N	E	G-E	E	E	G	E	E	F-G	G
Italian ryegrass	N	G	G	G	G	F	G	G	F	F-G
johnsongrass	N	G-E	G	G	G-E	F-G	G-E	G-E	P	P
little barley	N	E	E	E	E	E	E	E	G	G-E
sandbur	N	E	G-E	G-E	E	G	E	E	G	G
Texas panicum	N	E	E	G-E	E	G	E	E	G	G-E
volunteer corn (not RR vol.corn)	N	E	E	E	E	E	E	E	F	F-G
purple nutsedge	N	F-G	F-G	F-G	F-G	F-G	F-G	G	P-F	F
yellow nutsedge	N	P-F	P-F	P-F	P-F	F	P-F	F	P-F	F
BROADLEAVES										
bristly starbur	G	E	E	E	E	E	E	E	E	E
buttercup	G	G-E	E	E	G-E	G-E	G-E	G-E	E	E
Carolina geranium	F	P-F	F-G	G	F-G	G	G-E	G	G-E	E
chickweed	P	E	E	E	E	E	E	E	E	E
citronmelon	F	G-E	E	E	E	G-E	G-E	E	F	G
cocklebur	E	E	E	E	E	E	E	E	G-E	E
coffee senna	G	E	E	E	E	E	E	E	F	G
corn spurry	P-F	G-E	G-E		G-E	G-E		E	F-G	G-E
cowpea	G	E			E	E		E	E	E
cudweed	P	G-E	E	E	G-E	E	E	E	F-G	G
curly dock	P-F	F	F-G	G-E	F	P-F	E	F	N-P	P
cutleaf primrose	E	P-F	E	G	F	F-G	F	F-G	F[8]	G-E[8]
eclipta	P	G-E			G-E	G-E		G-E	F	F
Florida beggarweed	P-F	E	E	E	E	E	E	E	E	E
Florida pusley	F	F	G	G	G	F-G	F	F-G	F	F-G
field pansy	P-F	F	F-G	F-G			F	G	G	G-E
hemp sesbania	G-E	P-F	E		G-E	F-G			F	F-G
henbit	P	F	F-G	G	F-G	G	E	G	G	E[8]

WEED RESPONSE TO BURNDOWN HERBICIDES USED IN COTTON (continued)

Weed Species	Burndown Treatment [1]									
	2,4-D [3]	glyphosate	glyphosate acid [2] + 2,4-D [3]	glyphosate acid [2] + Clarity [4]	glyphosate acid [2] + Aim or ET	glyphosate acid [2] + diuron [7]	glyphosate acid [2] + Harmony Extra [5]	glyphosate acid [2] + Valor SX [6]	paraquat	paraquat + Direx [7]
horsenettle	F	F	F-G		P-F	F	F		P-F	F
horseweed	G-E[9]	G-E[10]	E[10]	E[10]	G-E[10]	G-E[10]	G-E[10]	G-E[10]	P-F	F-G
lambsquarters	E	F	E	E	G-E	G-E			F-G	G
morningglory, *Ipomoea*	G-E	F	E	E	E	G	F	E	F-G	G-E
morningglory, smallflower	F-G	G	E	E	G-E	G-E	G	E	P	F-G
Palmer amaranth	F[9]	E	E	E	E	E	E	E	F-G	G-E
Palmer amaranth (glyphosate-resistant)	F[9]	N	F[9]	F	P-F	G	N-P	P-F	F-G	G-E
Pennsylvania smartweed	F	G	G	E	G-E	G	E		P-F	F-G
prickly sida	F-G	F-G	G	E	F-G	F-G	F-G		P-F	F-G
purslane	G-E	F	G-E	E	F-G	G	F	G	G	G-E
ragweed	E	G	E	E	G-E	G			G	G
redweed	F	G		G-E	G-E	G			F	G
shepherdspurse	G	G			G	G			G	G
sicklepod	F-G	G-E	E	E	G-E	E	G-E	E	E	E
speedwell	P-F	E	E	E	E	E	E	E	G	E
spurred anoda	F-G	G			G	G			F-G	F-G
swinecress	F	F-G	G	F-G	F-G	G	G-E	F-G	P-F	F-G
tropic croton	F	G-E	G-E	G-E	G-E	G-E		E	F	F-G
tropical spiderwort	G-E	P	G-E	P-F	Aim = G-E ET = P-F	F	P	G	G	G-E
velvetleaf	F-G	G			G	G			P	P
vines (maypop, trumpet creeper)	F	P-F			P-F	F			P	P
Virginia pepperweed	G-E	G	E	G-E	G	G	G	G-E	G	G
volunteer peanuts	P	F	P-F	F-G	F-G	F-G	F	F-G	P	P-F
wild lettuce	G	G-E	G-E	G-E	G-E	G-E	G-E	E	P	F
wild poinsettia	F-G	G			G-E	G-E			G-E	G-E
wild radish	G	F-G	E	G-E	G	G	E	G	F-G	G-E
COVER CROPS										
clover	F	F	F-G	F-G	F	F-G			F-G	G-E
lupine	G	G	G		G	G			F-G	F-G
small grains	N	E	E	E	E	F-G	E	E	G[11]	G-E[11]
vetch	G-E	F	E	E	F	F-G	G	F-G	P-F[8]	F-G[8]

Key**:** E = 90% or better control; G = 80% to 90% control; F = 60% to 80% control; P = 30% to 60% control; N = < 30% control.

[1]Application rates per acre: Clarity: 0.5 pt; 2,4-D: 1 pt; Aim: 1 oz; ET: 1-2 oz; diuron: 0.5 to 1.0 lb a.i.; glyphosate acid: 0.75 to 1.12 lb a.e.; paraquat: 0.75 to 1.0 lb a.i.; Harmony Extra TotalSol: 0.75 oz; Valor: 2 oz.

[2]Mixing herbicides with glyphosate occasionally reduces grass control (including covercrops). This is more likely with large weeds in dry conditions.

[3]Labels for 2,4-D are ambiguous concerning the waiting period between application and planting, see label of specific brand used.

[4]Following application of Clarity and a minimum of 1 inch of rainfall, a minimum 21-day waiting period before planting is required.

[5]Harmony Extra, Nimble, or Express should be applied at least 14 days prior to planting.

[6]See plant back restrictions noted in the previous cotton section or on the label for Valor.

[7]See previous section on special state label for reduced plant back intervals with Direx.

[8]This level of control requires plants to be in full bloom with seed forming when treated.

[9]This level of control requires 1.5 to 2 pt of 2,4-D (4 lb a.i. product).

[10]Glyphosate resistant horseweed is likely present in some areas, glyphosate will not control glyphosate-resistant horseweed.

[11]Small grain must have visible seedheads for this level of control.

Note: Ratings based upon average to good soil and weather conditions for herbicide performance and upon proper application rate, technique, and timing.

WEED RESPONSE TO HERBICIDES USED IN COTTON

A. Stanley Culpepper, Extension Agronomist-Weed Science

	Preplant Incorporated		Preemergence						Residual Control by (Assuming soil contact)		
Weed Species	**Prowl**	**Treflan others**	**Prowl[1]**	**Com-mand**	**Cotoran others**	**Direx**	**Reflex**	**Staple**	**War-rant**	**Dual Magnum**	**Staple**	**Envoke**
Perennials bermudagrass	N	N	N	P-F	N	N	N	N	N	N	N	N
johnsongrass (rhizome)	P	P	P	N	N	N		N	P	P	N	N
yellow nutsedge	N	N	N	N	N	N	G-E	F	P	F	P-F	
purple nutsedge	N	N	N	N	N	N	P-F	F	P	P	F	
Annual Grasses broadleaf signalgrass	G	G	F	E	P	P	F-G	P	G	F-G	P	P
crabgrass	E	E	G	E	F-G	F-G	F-G	P	E	E	P	P
crowfootgrass	E	E	G	G	F-G	F-G		P	E	E		P
fall panicum	G	G	F-G	G-E	F	P		P-F	G	G	P-F	P
foxtails	E	E	G	E	F-G			P	E	E	P	P
goosegrass	E	E	G	E	F	F		P-F	E	E	P-F	P
johnsongrass (seedling)	E	E	G	G	P	P		F-G	F	F	F	P
sandbur	E	E	G	F-G	G	G			F-G	F-G		P
Texas panicum	G	G	F	F	P	P	F	N	P	P	N	P
Annual Broadleaves bristly starbur	N	N	N	P	G-E	F-G	G-E	F-G	P	P	G	G-E
burgherkin	N	N	N	P	F-G	F		F-G	P	P	F-G	
citronmelon	N	N	N	P	F-G	F		F-G	P	P	F-G	
cocklebur	N	N	N	F	F-G	F	G	N-P	P	P	N-P	
coffee senna	N	N	N	P	F-G	F	N	G	P	P	G	
cowpea	N	N	N	N-P	P	P		F-G	P	P	F-G	
crotalaria	N	N	N		G	G			P	P		
eclipta	P	P	P		G	G	G-E			P		
Florida beggarweed	P	P	P	F-G	G-E	G	P	G	P	P	G	F
Florida pusley	E	E	F-G	F-G	F-G	P-F	P	F	G	G	F	P
hemp sesbania	N	N	N	F	P	P	P	P	P	P	P	
jimsonweed	N	N	N	G	G	G		F-G			F-G	
lambsquarters	G-E	G-E	G	G	G-E	G-E	E	G	F	F	G	
morningglories *Ipomoea* smallflower	P P	P P	P P	P-F[2] P	G G-E	F G	PF GE	F[3]	P P	P P	F[3]	P
Palmer amaranth	F-G	F-G	P-F	N-P	F	G	E	G-E[3]	G	G	G-E[3]	P
pigweeds: redroot or smooth	G-E	G-E	F-G	P	G-E	G-E	E	E	G E	G-E	G-E	F
prickly sida	N	N	N	E	G	F		G	F	F	G	
purslane	E	E	G	G-E	E	E	G	G	G	G	G	
ragweed	N	N	N	G	E	G	G	N-P	P	P	N-P	
redweed	N	N	N	G-E	E	G-E		G-E			G-E	
smartweed: ladysthumb Pennsylvania	N N	N N	N N	N E	G G	G G		G G			G G	
sicklepod	N	N	N	P	G	F	P	P-F	P	P	P	P
spurge	N	N	N	N	P-F	F		G	P	P	G	
tropic croton	N	N	N	E	F-G	F-G	F-G	F-G	P	P	F	
tropical spiderwort	N	N	N	F	F	P-F	N	P	E	E	P	
volunteer peanuts	N	N	N	N	P-F	P	P	P	N	N	P	P
wild poinsettia	N	N	N	F	N	N	G-E	G	P	P	G	

[1]Assumes irrigation or rainfall occurs within 48 hrs.
[2]Fair on pitted morningglory.
[3]Staple does not control tall morningglory or ALS-resistant Palmer amaranth.

Key**:** E = 90% or better control; G = 80% to 90% control; F = 60% to 80% control; P = 30% to 60% control; N = < 30% control.
Note: Ratings based upon average to good soil and weather conditions for herbicide performance and upon proper application rate, technique, and timing.

Weed Species	POST OVER-THE-TOP					
	Assure	Fusilade	Poast	Select/Select Max	MSMA[1]	Cotoran
Perennials						
bermudagrass	G	G	F	G	N	N
johnsongrass (rhizome)	E	G-E	G	G-E	P	N
purple nutsedge	N	N	N	N	N-P	N
yellow nutsedge	N	N	N	N	P	N
Annual Grasses						
broadleaf signalgrass	G	G-E	E	E	P	P
crabgrass	G	G	G-E	G-E	P	P-F
crowfootgrass	G	F	F-G	G	P	P-F
fall panicum	G-E	G-E	E	E	P	P-F
foxtails	E	E	E	E		
goosegrass	G	G	G-E	G-E	P	P-F
johnsongrass (seedling)	E	G-E	G-E	E	P	P
sandbur		G	G	G	P	P
Texas panicum	G	G	E	E	N-P	N
Annual Broadleaves						
bristly starbur	N	F-G	N	N	P	G
burgherkin	N	N	N	N	P-F	F-G
citronmelon	N	N	N	N	P-F	G
cocklebur	N	N	N	N	E	F-G
coffee senna	N	N	N	N	P-F	F-G
cowpea	N	N	N	N	F	F-G
crotalaria	N	N	N	N	F	G
eclipta	N	N	N	N		
Florida beggarweed	N	N	N	N	E	G
Florida pusley	N	N	N	N	N-P	P-F
hemp sesbania	N	N	N	N		
jimsonweed	N	N	N	N	P	G
lambsquarters	N	N	N	N	P	G
morninglories	N	N	N	N	P-F	G
Palmer amaranth	N	N	N	N	P	P-F
pigweeds: smooth and redroot	N	N	N	N	P	F
prickly sida	N	N	N	N	P	F-G
purslane	N	N	N	N	P-F	F-G
ragweed	N	N	N	N	P-F	G
redweed	N	N	N	N	N	F-G
sicklepod	N	N	N	N	P-F	F-G
smartweed: ladysthumb	N	N	N	N	N-P	F-G
Pennsylvania	N	N	N	N	N-P	F-G
spider flower	N	N	N	N		F
spurge	N	N	N	N	N	P-F
tropic croton	N	N	N	N	F	F-G
tropical spiderwort	N	N	N	N	P	P
volunteer peanuts	N	N	N	N	P	F
wild poinsettia	N	N	N	N	P	F

[1]MSMA is no longer labeled for this use but ratings are provided for existing stocks with previous labeling.

Key**:** E = 90% or better control; G = 80% to 90% control; F = 60% to 80% control; P = 30% to 60% control; N = < 30% control.

Note: Ratings based upon average to good soil and weather conditions for herbicide performance and upon proper application rate, technique, and timing.

Weed Species	POST OVER-THE-TOP						
	Staple	Envoke	Envoke + Staple	glyphosate[2]	glyphosate[2] + Staple	glyphosate[2] + Envoke	Liberty[3]
Perennials							
bermudagrass	N	N	N	F	F	F	N
johnsongrass (rhizome)	N-P	P	N-P	G-E	G-E	G-E	F
purple nutsedge	P-F	F-G	F-G	F-G	F-G	E	F
yellow nutsedge	P-F	G	G	F	F-G	E	F
Annual Grasses							
broadleaf signalgrass	N	N	N	E	E	E	G
crabgrass	N	P	P	E	E	E	G
crowfootgrass	N	N	N	E	E	E	G
fall panicum	N	N-P	P	E	E	E	G
foxtails	N-P	N-P	N-P	E	E	E	G
goosegrass	N-P	N-P	N-P	E	E	E	P
johnsongrass (seedling)	P	F	P-F	E	E	E	G
sandbur	P			E	E	E	G
Texas panicum	N	N-P	P	E	E	E	G
Annual Broadleaves							
bristly starbur	G	G-E	G-E	E	E	E	G
burgherkin	G			G-E	G-E	G-E	
citronmelon	G-E	G-E	G-E	G-E	E	E	G
cocklebur	G	G-E	E	E	E	E	E
coffee senna	G			E	E	E	G
cowpea	G	G	G-E	E	E	E	G
crotalaria				G	G	G	
eclipta	G	P-F		E	E	E	G
Florida beggarweed	G	G-E	G-E	E	E	E	G
Florida pusley	N-P	P	P	P-G	P-G	P-G	F
hemp sesbania	G-E			P-F	G-E		
jimsonweed	E	N		E	E	E	E
lambsquarters	N	G		G	G	E	E
Ipomoea morningglory	G[1]	G	G-E	F-G	G-E	E	E
Smallflower morningglory	E	N	E	G	E	G	E
Palmer amaranth	F	P-F	F	E	E	E	F-G
Palmer amaranth (glyphosate-resistant)	F	P-F	F	N	F	P-F	F-G
Palmer amaranth (glyphosate-and ALS resistant)	N	N	N	N	N	N	F-G
pigweed: smooth and redroot	G	F-G	G	E	E	E	G
prickly sida	F	N	F	F-G	G	G	F
purslane	F			F-G	G	G	F-G
ragweed, common	P	G		E	E	E	E
redweed	G			E	E		
sicklepod	P-F	E	E	E	E	E	E
smartweed: ladysthumb	G	G		G	E	E	E
Pennsylvania	G	G		G	E	E	G
spider flower							
spurge	F-G			G	G	G	F-G
tropic croton	P	P-F	P-F	E	E	E	G
tropical spiderwort	F	P-F	F	P-G	G	P-G	P-F
volunteer peanuts	P	P-F		F-G	F-G	F-G	G-E
wild poinsettia	F	G		G-E	G-E	E	P-F

[1]Staple does not control tall morningglory.
[2]Glyphosate should be applied only to glyphosate-resistant cultivars. All formulations of glyphosate are not labeled for this use.
[3]Liberty should be applied to cotton tolerant of Liberty such as LibertyLink or GlyTol/Liberty Link cotton.

Key: E = 90% or better control; G = 80% to 90% control; F = 60% to 80% control; P = 30% to 60% control; N = < 30% control.
Note: Ratings based upon average to good soil and weather conditions for herbicide performance and upon proper application rate, technique, and timing.

Weed Species	POSTEMERGENCE-DIRECTED							
	MSMA	Cotoran + MSMA	Caparol + MSMA	Direx, others + MSMA	Direx + Linex + MSMA	Cobra + MSMA	Valor + MSMA	Suprend + MSMA
Perennials bermudagrass	N	N	N	N	N	N	N	N
johnsongrass (rhizome)	P	P	P	P	P	P	P	P
purple nutsedge	F	F	F	F	F	F	F-G	E
yellow nutsedge	F-G	F-G	F-G	G	G	F-G	G	E
Annual Grasses broadleaf signalgrass	F	F	F-G	G	G	P-F	F	F-G
crabgrass	F	F	F-G	G	G	P-F	F	F-G
crowfootgrass	F	F	F-G	F-G	F-G	P-F	F	F-G
fall panicum	F	F	F-G	F-G	F-G	P-F	F	F-G
foxtails	F	F	F-G	F-G	F-G	P-F	F	F-G
goosegrass	F	F	F-G	F-G	F-G	P-F	F	F-G
johnsongrass (seedling)	F	F	F-G	F-G	F-G	P-F	F	F-G
sandbur	F	F	F-G	F-G	F-G	P-F	F	F-G
Texas panicum	P	P	F	F	F	P	P-F	F
Annual Broadleaves bristly starbur	P-F	G	G	G	G	G	G	G-E
burgherkin	F	F-G	G	G	G	G		
citronmelon	F	G	F-G	G	G	G		
cocklebur	E	E	E	E	E	E	E	E
coffee senna	F	G	G	G	G	F	G	
cowpea	F-G	G	G	G	G	F-G	G	
crotalaria	G	G	G	G	G	G		
eclipta		G	G	E	E	E	E	E
Florida beggarweed	E	E	E	E	E	E	E	E
Florida pusley	P	F	F	F	F	F	F-G	F
hemp sesbania	N	P-F	P-F	P-F		F		
jimsonweed	F	G-E	G	G	G	G-E	E	G
lambsquarters	P-F	G	G	G	G	F	F-G	G-E
morninglories	P	F-G	G	G	G-E	E	E	E
Palmer amaranth	P	F	F	G-E	G-E	F	F-G	G-E
pigweeds: redroot or smooth	P-F	G	G	G-E	G-E	G	G-E	G-E
prickly sida	P	F-G	G-E	G-E	G-E	G-E	G-E	G-E
purslane	P-F	F-G	F-G	G	G	G	G	
ragweed, common	F	G-E	E	E	E	E	G-E	E
redweed	N	F-G	G	G-E		F		
sicklepod	F	G	G-E	G-E	G-E	P-F	G-E	E
smartweed: ladysthumb & Penn	P	G	F	F	F	F	G	
spider flower	G-E (in bloom)	G-E (in bloom)	G-E (in bloom)	G-E (in bloom)	G-E (in bloom)	G-E (in bloom)		
spurge	N	P-F	G	G	G	G	G	
tropic croton	F	G	G	G	G	E	E	G-E
tropical spiderwort	F	G	F-G	G	G	F-G	G-E	F-G
volunteer peanuts	P-F	F-G	F-G	G	G	P-F	F-G	G
wild poinsettia	P-F	F	P-F	P-F		G	G	

Key**:** E = 90% or better control; G = 80% to 90% control; F = 60% to 80% control; P = 30% to 60% control; N = < 30% control.
Note: Ratings based upon average to good soil and weather conditions for herbicide performance and upon proper application rate, technique, and timing.

Weed Species	POSTEMERGENCE-DIRECTED (continued)							HOOD
	glyphosate[1]	glyphosate[1] + Direx	glyphosate[1] + Aim	glyphosate[1] + Envoke	glyphosate[1] + Staple	glyphosate[1] + Valor	Liberty[2]	Gramoxone[3]
Perennials bermudagrass	F	F	F	F	F	F	N	P
johnsongrass (rhizome)	G-E	G	G-E	E	G-E	G-E	F	P
purple nutsedge	F-G	G	F-G	E	F-G	G	P	P-F
yellow nutsedge	F	F-G	F	E	F-G	G	P	P-F
Annual Grasses broadleaf signalgrass	E	G-E	E	E	E	E	G	G-E
crabgrass	E	G-E	E	E	E	E	F-G	G
crowfootgrass	E	G-E	E	E	E	E	G	G
fall panicum	E	G-E	E	E	E	E	G	G
foxtails	E	G-E	E	E	E	E	G	G
goosegrass	E	G-E	E	E	E	E	P	G
johnsongrass (seedling)	E	G-E	E	E	E	E	G	G
sandbur	E	G-E	E	E	E	E	G	G
Texas panicum	E	G-E	E	E	E	E	G	G
Annual Broadleaves bristly starbur	G-E	G-E	G-E	G-E	G-E	E	G	E
burgherkin	G	G	G		G			F
citronmelon	G-E	G-E	G-E	E	E	E	G	G
cocklebur	E	E	E	E	E	E	E	G
coffee senna	E	E	E	E	E	E	G	F
cowpea	G-E	G-E	G-E	G-E	G-E	E	G	G
crotalaria	G	G	G		G			
eclipta	E	E	E	E	E	E	G	F
FL beggarweed	E	E	E	E	E	E	G	E
Florida pusley	P-G	G	G	P-G	P-G	G-E	F	P-F
hemp sesbania	P-F		G-E		G-E			F
jimsonweed	E	E	E	E	E	E	E	G
lambsquarters	G	G-E	G-E	G-E	G-E	G-E	E	F
morning glory - *Ipomoea*	F-G	G-E	E	E	G-E	E	E	F-G
morningglory - smallflower	G	E	E	G	E	E	E	P-F
Palmer amaranth	E	E	E	E	E	E	F-G	G-E[3]
Palmer amaranth (glyphosate-resistant)	N	F-G	P-F	P	F	P-F	F-G	G-E[3]
Palmer amaranth (glyphosate & ALS resis.)	N	F-G	P-F	N	N	P-F	F-G	G-E[3]
pigweed: redroot or smooth	E	E	E	E	E	E	G	G-E[3]
prickly sida	F-G	G	F-G	F-G	G	G-E	F-G	P-F
purslane	F-G	G-E	G			G-E	F-G	G
ragweed, common	E	E	E	E	E	E	E	F
redweed	G-E	G-E	G-E		G-E			F-G
sicklepod	E	E	E	E	E	E	E	G-E
smartweed:	G	G	G-E	E	E	G	G-E	G
spider flower			G			G		
spurge	G	G-E	G-E	G	G	G	F-G	
tropic croton	E	E	E	E	E	E	G	F
tropical spiderwort	P-F	F-G	G-E	P-F	F-G	G-E	P-F	G-E
volunteer peanuts	F	G	F-G	F-G	F	F-G	G-E	P
wild poinsettia	G	G	G-E	E	G	G-E	P-F	G

[1]Glyphosate should be applied only to glyphosate-resistant cotton.
[2]Liberty should be applied only to cultivars tolerant of Liberty. Must apply to grasses two inch or smaller.
[3]The addition of diuron with Gramoxone is needed for this level of control.
Key**:** E = 90% or better control; G = 80% to 90% control; F = 60% to 80% control; P = 30% to 60% control; N = < 30% control.
Note: Ratings based upon average to good soil and weather conditions for herbicide performance and upon proper application rate, technique, and timin

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ATTENTION!
PESTICIDE PRECAUTIONS

1. **Observe all directions, restrictions and precautions on pesticide labels. It is dangerous, wasteful, and illegal to do otherwise.**
2. **Store all pesticides in original containers with labels intact and behind locked doors. "KEEP PESTICIDES OUT OF THE REACH OF CHILDREN."**
3. **Use pesticides at correct label dosage and intervals to avoid illegal residues or injury to plants and animals.**
4. **Apply pesticides carefully to avoid drift or contamination of non-target areas.**
5. **Surplus pesticides and containers should be disposed of in accordance with label instructions so that contamination of water and other hazards will not result.**
6. **Follow directions on the pesticide label regarding restrictions as required by State or Federal Laws and Regulations.**
7. **Avoid any action that may threaten an Endangered Species or its habitat. Your county Extension agent can inform you of Endangered Species in your area, help you identify them, and through the Fish and Wildlife Service Field Office identify actions that may threaten Endangered Species or their habitat.**

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